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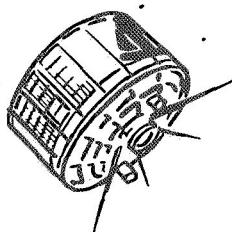
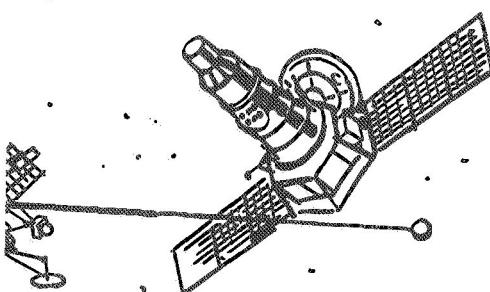
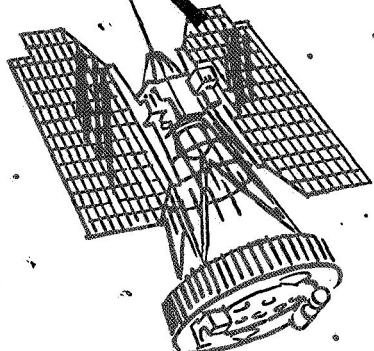
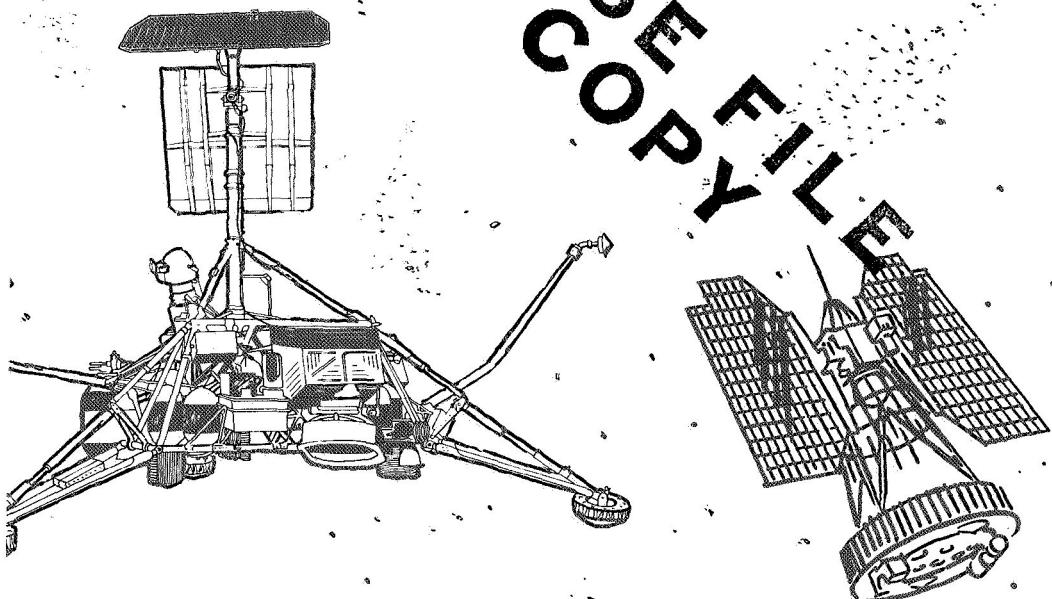
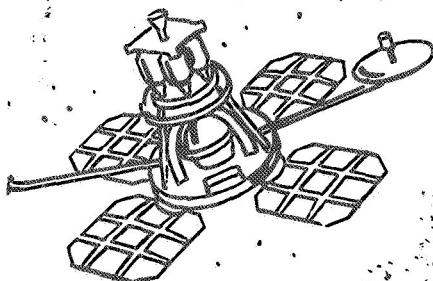
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SEMIANNUAL  
REPORT TO  
CONGRESS

JANUARY 1 - JUNE 30, 1968

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TO THE CONGRESS OF THE UNITED STATES:

I am proud to transmit the Nineteenth Semiannual Report of the National Aeronautics and Space Administration, covering the period January 1 through June 30, 1968.

This was a period of gratifying progress in the Nation's space effort. Project Apollo was within sight of its first manned flights—culminating in the magnificent flight of three brave astronauts in Apollo 8. At the same time, our satellites continued to provide meteorological and weather information to be used for the benefit of people all over the world, and to maintain channels for expanding and hastening communications among all nations.

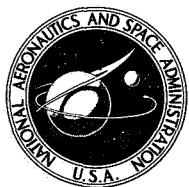
I am pleased to bring this report to your attention.

A handwritten signature in black ink, appearing to read "Lyndon B. Johnson".

THE WHITE HOUSE, January 17, 1969.

**Nineteenth  
SEMIANNUAL  
REPORT TO  
CONGRESS**

JANUARY 1 - JUNE 30, 1968



**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
WASHINGTON, D. C. 20546**

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For sale by the Superintendent of Documents, U.S. Government Printing Office  
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January 15, 1969.

THE PRESIDENT  
*The White House*

DEAR MR. PRESIDENT:

I am very pleased to submit this Nineteenth Semiannual Report of the National Aeronautics and Space Administration, covering the period January 1-June 30, 1968, for transmittal to Congress in accordance with section 206(a) of the National Aeronautics and Space Act of 1958.

These months were filled with constructive activity culminating in such concrete advances as the successful Apollo 5 and 6 unmanned orbital missions which moved the manned space flight program into readiness for the first manned Apollo flights, the landing of the last of the Surveyor series on the Moon for a highly productive period of TV transmission and experiments on the lunar surface, and the launching and operation of a number of other scientific, weather, and communications satellites.

The accomplishments recorded here, along with the many supporting activities described in detail, prepared the way for continued progress in the Apollo program and the scheduled achievement of the manned flights called for in that program. It is a highly satisfactory record and evidence that the Nation is advancing steadily in its efforts to conquer space for the benefit of all.

Respectfully yours,

T. O. Paine,  
*Acting Administrator.*



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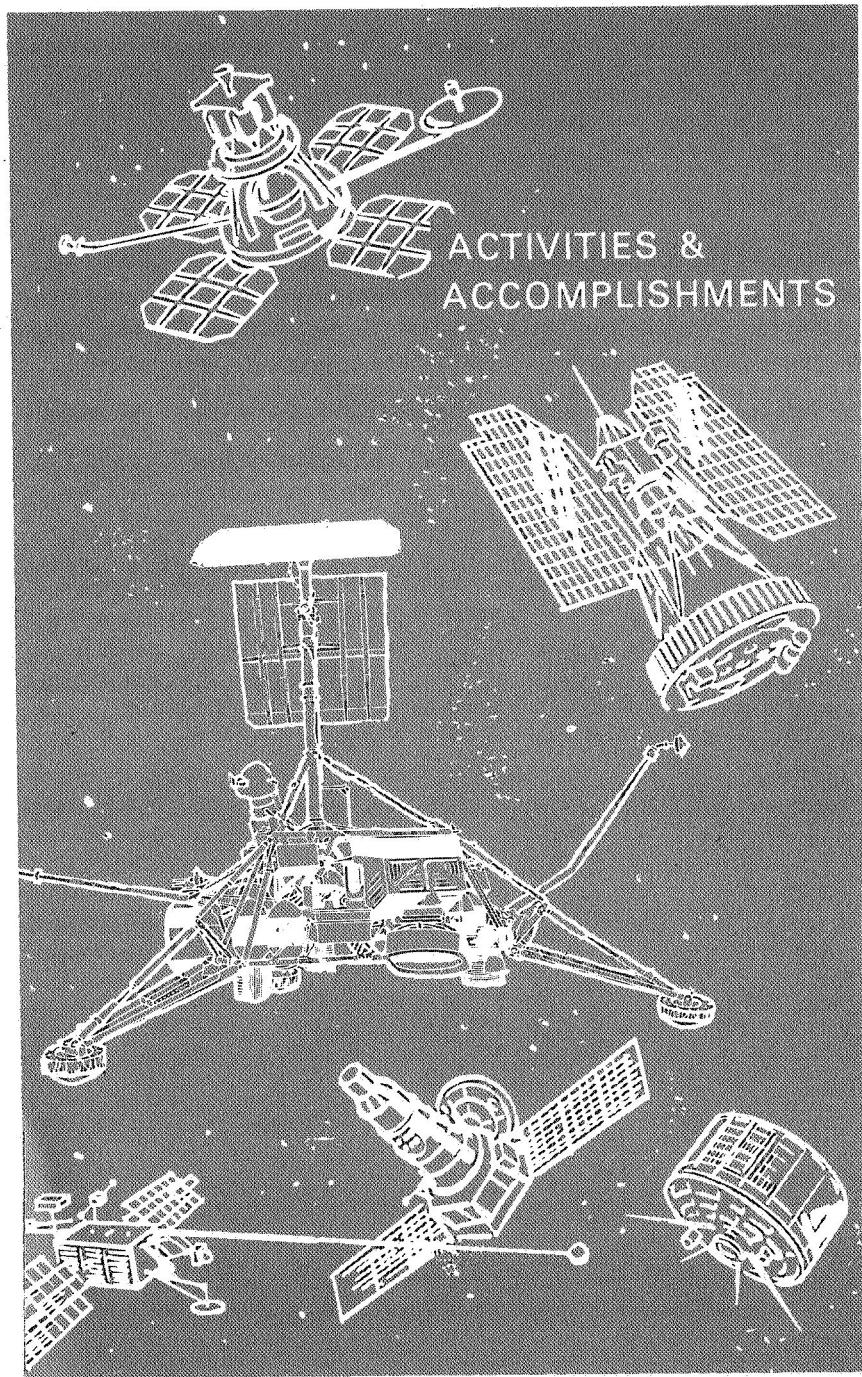
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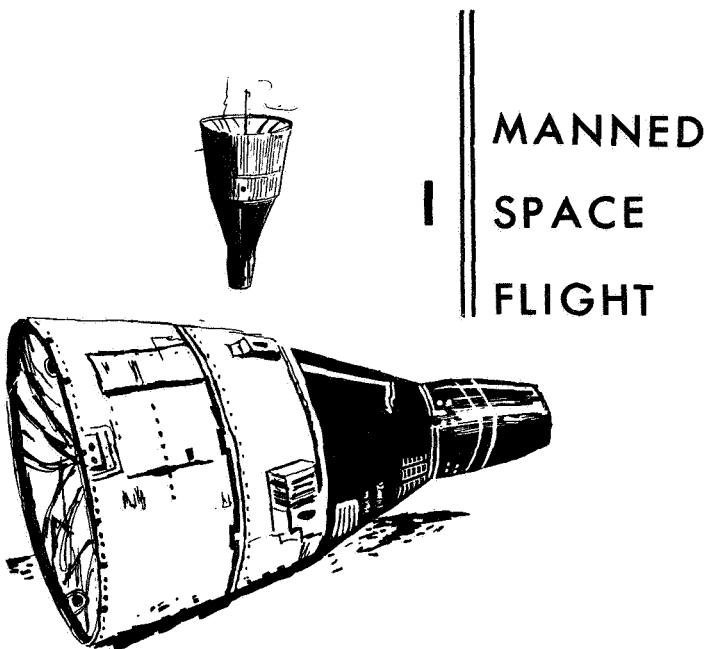
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NASA's manned space flight achievements in the Apollo program during this period included the first unmanned flight of the Lunar Module, the second unmanned mission using the Saturn V launch vehicle; major decisions affecting the Apollo launch and flight operations schedule; and continued concerted efforts to improve spacecraft delivery schedules.

In addition, further progress was made in mission planning and hardware development for the Apollo Applications program, and more detailed studies of advanced manned missions for the post-Apollo period were conducted.

Progress continued in strengthening both the management efforts associated with manned space flight and the industrial base. The NASA-industry manned space flight team further upgraded its organizational structure and managerial capabilities.

Intensive training continued for the astronauts selected as primary and back-up crews for the first three manned Apollo flights. The scientist-astronauts selected in 1967 entered flight training, and general training continued for others.

### Apollo Program

NASA completed several critical milestones in the Apollo Program. Apollo 5, successfully flown on January 22, was an unmanned earth orbital flight conducting the first test in space of the Lunar Module.

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Apollo 6, launched on April 4, was the second Apollo mission to use the Saturn V launch vehicle. It boosted into orbit a lunar module test article (LTA-2R) and a command and service module flight test article (CSM 020). After the Apollo 6 flight, NASA decided to plan the Apollo 8 (A/S 503) as a manned flight and the Apollo Program launch schedule was revised accordingly.

The Apollo Program is a major step in the total national program to develop a broad capability for the manned exploration of space. The goal is to accomplish a manned lunar landing and return mission within this decade.

NASA made several decisions having a major impact on the Apollo Program. After analyzing the data gathered from an extensive command module flammability test program and consideration of a variety of contingencies and biomedical factors, the Agency selected a pre-launch command module cabin atmosphere of 60 percent oxygen and 40 percent nitrogen at 16.2 p.s.i. After lift off, this atmosphere would gradually change to reach a cabin atmosphere of 100 percent oxygen at 5.0 p.s.i. near orbit insertion time. The National Academy of Science indicated general agreement with this decision.

Following the flight of Apollo 5 with the Lunar Module 1, the Agency decided a second lunar module flight was not necessary. This decision made Lunar Module 2 available for ground test and the SA 206 launch vehicle available for the alternate mission phase.

A major challenge that continued to face the Apollo Program was to achieve the on-schedule delivery to KSC of completed flight hardware. To assure such delivery, the ground rules for hardware changes were tightened, and change control systems were rigidly enforced at Center and Contractor levels.

#### **Apollo 5 Mission**

NASA defined the Apollo 5 mission as a Lunar Module Development Mission. Its primary objectives were to verify the Lunar Module structure, and the operation of the ascent and descent propulsion systems, including restart; to evaluate Lunar Module staging (ascent propulsion system operation to separate the ascent stage from the descent stage); and to evaluate the S-IVB orbital performance.

The Apollo 5 launch from Complex 37B, Cape Kennedy, occurred at 5:48 p.m., e.s.t. on January 22 (fig. 1-1); the mission was completed at 2:45 a.m., e.s.t., the following morning (January 23). This was the fourth unmanned flight of the Saturn IB and the first for the Apollo spacecraft Lunar Module. All primary objectives were achieved.

The SA-204 launch vehicle stages and components contained R&D instrumentation, and engine thrust was not at the uprated level. The LM-1 spacecraft differed from the final lunar module configuration

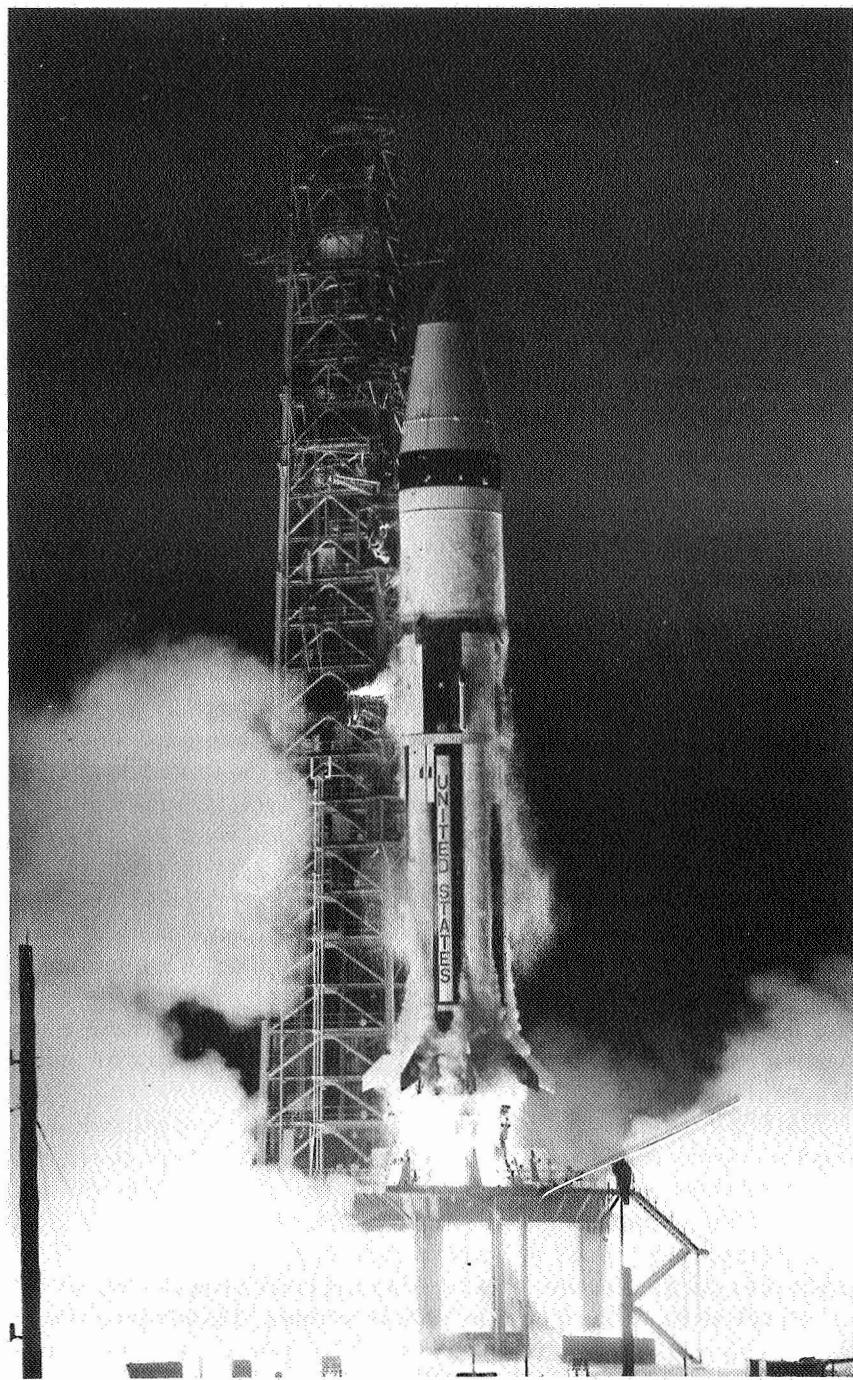


Figure 1-1. Apollo 5 Launch, January 22, 1968.

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by deletion of the abort guidance system, landing gear, and crew provisions; by partial deletions in the environmental control, communications, and display systems; by substitution of aluminum panels for the three windows; and by the addition of R&D instrumentation and a LM Mission Programmer. The LM cabin was filled with gaseous nitrogen. The nitrogen was allowed to leak without replenishment in flight. A nose cone replaced the command and service modules atop the spacecraft LM adapter (SLA).

Lift-off and flight trajectory were very close to nominal. The S-IB stage and S-IVB stage propulsion systems performed satisfactorily throughout the flight. The S-IVB inserted the Lunar Module into an 88 by 120 nautical mile orbit. The nose cone was jettisoned from the space vehicle 35 seconds after insertion. At approximately 20 minutes after lift-off the SLA panels were deployed.

After the LM had made 2½ revolutions of the earth, one of the ground stations commanded the first descent propulsion system (DPS) burn. Shortly afterward, however, there was a premature engine cutoff.

Because of this premature cutoff, controllers modified the mission plan and selected an alternate. This alternate mission had been previously planned to achieve basic minimum mission objectives. The major differences between the two missions were the deletion of a long (12-minute) DPS burn and the substitution of program reader assembly (PRA) control for primary guidance during the propulsion burns. The second DPS burn was then commanded. The duration of this burn was 33 seconds. This was followed by a 32-second coast period and a third DPS burn of 28 seconds.

Fire-in-the-hole abort stage separation was accomplished by firing the ascent propulsion system (APS). Burn duration was 60 seconds. Subsequently, there was a second APS burn of about six minutes.

After the primary portion of the mission was completed, engineers did not continue with the extended mission activities because there was not enough Reaction Control System (RCS) propellant to maintain attitude control.

The LM-1 ascent stage was rate-stabilized in the retro attitude during the second APS burn. Data indicates that this stage re-entered the atmosphere west of Hawaii during the sixth orbit. The descent stage re-entered the atmosphere over the Pacific Ocean on February 12.

In general, the ground systems performance was satisfactory. Two problems with ground equipment during the launch countdown caused the launch to be delayed 3 hours and 48 minutes. These were a freon flow problem affecting the spacecraft and a power supply problem in the digital data acquisition system of the automatic ground control station.

Spacecraft ground support equipment (GSE) systems on the launch pad, and the umbilical tower at Launch Complex 37 indicated no visible damage resulting from heat or blast effects during launch. Damage to launch vehicle GSE and pad facilities was minor (superficial damage which was, in most cases, less than anticipated).

#### Apollo 6 Mission

Apollo 6 was the second Saturn V mission in the launch vehicle and spacecraft development flight phase. Its primary objectives were to demonstrate the structure and thermal integrity and compatibility of the launch vehicle and spacecraft; to confirm launch loads and dynamic characteristics; to demonstrate stage separation; to verify operation of the propulsion, guidance and control, and electrical systems; to evaluate performance of the space vehicle emergency detection system in a closed-loop configuration; and to demonstrate mission support facilities and operations required for launch, mission conduct, and CM recovery. (Fig. 1-2.)

The Apollo 6 mission took place on April 4, with launching from Complex 39A at the Kennedy Space Center. Plans called for a Command Module flight duration of 9 hours and 49.75 minutes. Apollo 6

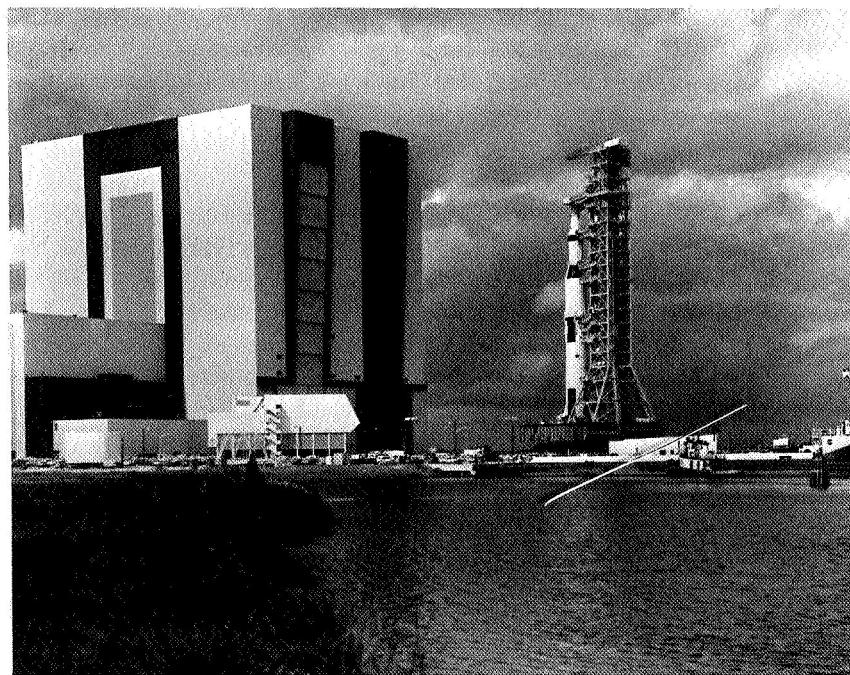


Figure 1-2. Apollo 6 arriving at Pad A, Launch Complex 39.

attained all but one of its primary objectives. Restart of the S-IVB stage in orbit did not occur. (Fig. 1-3.)

For test purposes, SA-502 stages and components differed slightly from the final space vehicle configuration. R&D instrumentation was flown. The S-II stage structure was of the heavy weight design. A helium heater was deleted from the S-IVB stage. Engine thrust was not at the uprated level. The Block I Command and Service Modules were equipped with R&D instrumentation, a programmer, a Van Allen belt dosimeter, a unified hatch, hand rails, a post-landing vent valve, and a Block II heat shield. The Service Module carried external insulation. The couches, crew restraints, crew provisions, S-band high gain antenna, and portions of the Stabilization and Control System were deleted. A Lunar Module test article, LTA-2R, was carried. The Adapter and Launch Escape System were in the final configuration, with the boost protective cover modified to accomodate hand rails on the spacecraft.

Following lift-off, the S-IC stage performed satisfactorily, although the outboard engines were shut down slightly later than predicted. During the latter portion of first stage boost, a severe longitudinal oscillating acceleration occurred. At the time of maximum "q" excursion, an object separated from the space vehicle in the area of the SLA. This and other Apollo 6 problems are discussed under Technical Problems. S-IC/S-II first and second plane separations both occurred within 1.1 seconds of the predicted times. S-II separation camera film showed the separation to be smooth and the clearances adequate. The launch escape tower was jettisoned, as planned, 32 seconds after S-II stage ignition. (Fig. 1-4.)

While the S-II stage burn began in a normal fashion, engine No. 2 cut off prematurely (at 6 minutes and 48.7 seconds GET) ; engine No. 3 cut off about two seconds later. The control system remained stable and control was maintained for the remainder of the S-II burn. The remaining three engines appeared to cut off normally. The "engine out" condition resulted in a 58.0-second longer than nominal S-II burn and larger than planned deviations from the S-II flight pattern.

During S-IVB first burn, the stage systems performed normally. However, because of earlier deviations, the flight did not follow the planned program. The parking orbit had a 196 nm apogee and 96 nm perigee. After two revolutions in parking orbit, preparations were made for S-IVB re-start. All engine and stage pre-start conditions appeared normal for this re-start but mainstage ignition was never attained.

A ground command was then sent to the Command/Service Module (CSM) to implement a planned alternate mission. The CSM was

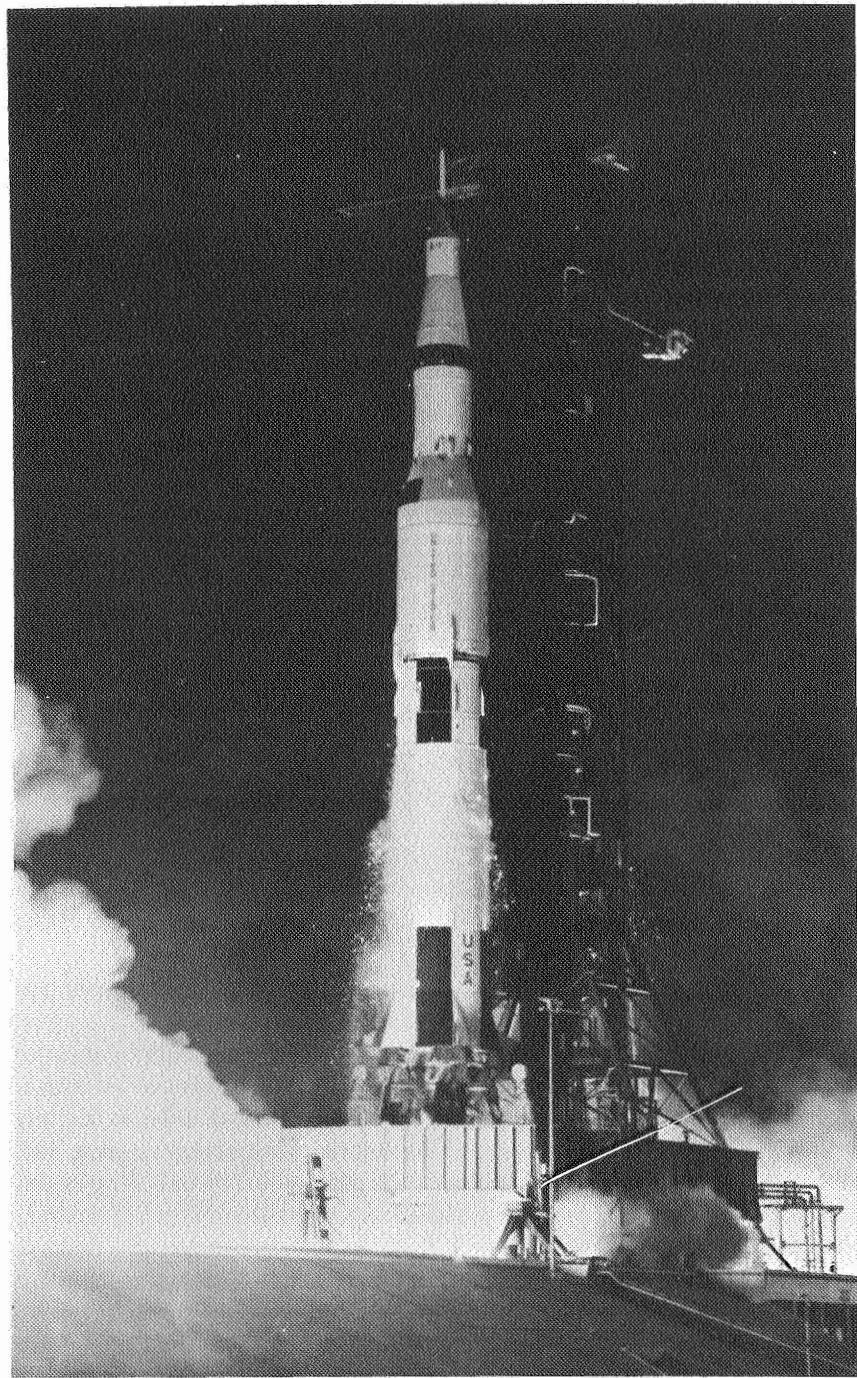


Figure 1-3. Launch of Apollo 6, April 4, 1968.

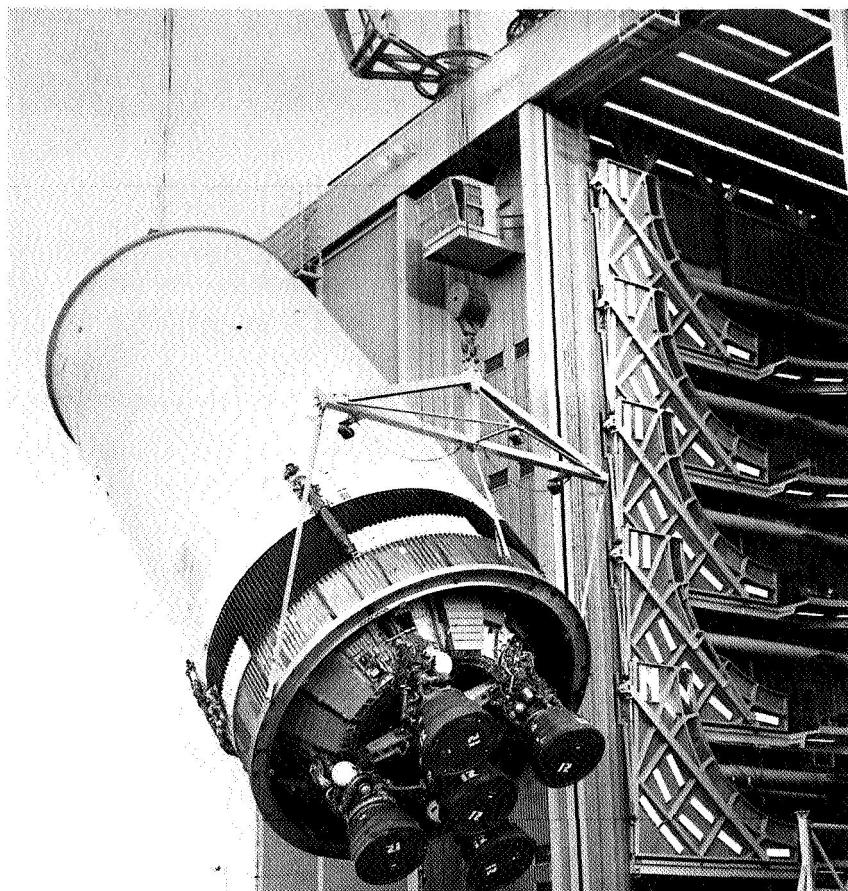


Figure 1-4. An S-II stage.

separated from the S-IVB stage about three hours and fifteen minutes ground elapsed time (GET).

The alternate mission selected used the service propulsion engine to transfer the spacecraft from the initial S-IVB insertion orbit into a highly elliptical orbit. The earth intersecting elliptical orbit achieved, following the 445-second firing of the service propulsion engine, had an apogee of 12,020 nm and a potential perigee of 18 nm. Engineers had hoped to fire the service propulsion engine a second time. However, the first firing consumed too much fuel. As a consequence, the desired reentry velocity could not be obtained. At 400,000 feet, the reentry conditions were a velocity of 32,819 ft/sec and a flightpath angle of 5.84° compared to the planned conditions of 38,243 ft/sec and 5.8°.

The spacecraft landed within 50 miles of the onboard targeted landing point, was recovered by the U.S.S. *Okinawa*, and was found to be

in good condition (including the crew hatch). Charring of the Command Module thermal protection appeared similar to that on the Apollo 4 spacecraft. Overall performance of the Command and Service Module was excellent.

As to the operational support for the launch, the countdown was completed without an unscheduled hold. Ground system performance was highly satisfactory. The relatively few problems encountered in countdown were overcome so that vehicle launch readiness was not compromised.

Launch damage to the complex and support equipment was minor. Modifications to the ground systems after launch of AS 501 were effective in reducing the amount of blast damage to a level below that sustained during the AS 501 launch.

Tracking and data network performance was satisfactory during the mission. Only minor problems were encountered, and none affected mission operations.

### Apollo 7 Mission

Apollo 7 is to be the first manned Apollo mission. This will be a Command and Service Module operations mission and will use a Saturn IB vehicle. The primary objectives are to demonstrate CSM/crew performance, to demonstrate crew/space vehicle/mission support facilities performance during a manned CSM mission, and to demonstrate CSM rendezvous capability.

The launch vehicle is to place the manned CSM in an elliptic orbit. The CSM will separate from the S-IVB on the second orbit, using the SM Reaction Control System. After separation, the CSM is to perform a transposition maneuver, followed by a simulated docking with the S-IVB stage. Primary emphasis during the orbital operations period will be on demonstrations of subsystems operations.

The SM propulsion system is to perform the nominal de-orbit burn. Touchdown is planned to occur in the Atlantic, near Bermuda.

The Saturn IB 205 launch vehicle stages and components will be the final design configuration, except that engine thrust will not be at the uprated level. The Block II Command and Service Modules will contain R&D instrumentation, and will have the unlitized crew couch. The modified Block I Adapter will contain acquisition lights and a docking target. A tiebar will replace the Lunar Module in the Adapter. The Launch Escape System will be the final configuration. A TV camera will be carried in the Command Module.

*Experiments.*—Experiments in synoptic terrain and weather photography, bone demineralization, cytogenetic blood studies, and lower body negative pressure will be performed.

*Operations.*—Factory checkout in preparation for delivery of the S-IB-5 stage to KSC started on January 2, following block modifications. The Apollo 7 space vehicle stages, instrument unit, service module, and Command module were received at KSC between March 28 and May 30. The launch vehicle was erected on launch complex 34 on April 18.

When the CSM arrived at KSC, it was placed in the vacuum chamber for simulated altitude tests and combined systems testing before being mated with the launch vehicle. Several problems were encountered in these pre-launch checks of this first Block II command and service module. An oxidizer spill during reaction control system (RCS) hypergolic fuel hot flow tests contaminated some antennas, cables, and connectors in the instrument unit, and replacement was necessary. Several RCS leaks in the spacecraft caused some delays. At the end of this reporting period, the spacecraft was in the vacuum chamber, and preparations for the manned altitude tests were underway. Launch vehicle pre-launch checks were progressing satisfactorily.

#### **Apollo 8 Mission**

The Apollo 8 (AS-503) mission was being planned as the first in the CSM-LM Operation phase. While plans called for it to be the first manned Saturn V space vehicle, NASA would retain the alternative to revert to an unmanned mission if necessary. The mission's primary objectives would be to demonstrate crew/space vehicle/mission support facilities performance during a manned Saturn V mission with a CSM and LM; to demonstrate LM/crew performance; and to demonstrate performance of planned and backup lunar orbit rendezvous mission activities. These activities would include pre-translunar injection procedures, transposition, docking, LM withdrawal, intravehicular and extravehicular crew transfer, docked service and descent propulsion systems burns, and LM active rendezvous and docking.

The launch vehicle would place the manned spacecraft in a circular orbit. The CSM would then separate from the launch vehicle, turn around, dock, and perform LM withdrawal. Several tasks would be performed while in orbit. These include unmanned S-IVB restart, extravehicular crew transfer, docked DPS and SPS burns, staging with the LM manned and separated from the CSM, LM active rendezvous, and an APS burn with the ascent stage unmanned and separated from the CSM. CSM and LM orbits throughout the mission would not exceed 300 nm altitude. Activity subsequent to the fifth day would involve the CSM only.

The AS-503 launch vehicle would be equipped with R&D instrumentation. The S-II stage structure would be of the heavyweight design, and engine thrust would not be at the uprated level. The spacecraft, adapter, and launch escape system would be in the final configuration but with R&D instrumentation added to the spacecraft.

The launch vehicle stages and a Boilerplate spacecraft, BP-30, for an unmanned mission were in pre-launch checkout at KSC on January 1. The launch vehicle stages were mated in the Vertical Assembly Building and the boilerplate spacecraft was added. Pre-launch preparations for an unmanned mission were proceeding satisfactorily.

However, following assessment of the Apollo 6 mission, NASA decided to plan and prepare for a manned mission on Apollo 8, though still retaining the capability to fly unmanned. Subsequently, the launch vehicle was demated, and the second stage (S-II-3) was shipped to the Mississippi Test Facility for cryogenic proof pressure testing, a test constraining manned flight.

All planning was revised to prepare for the possible manned flight. The S-II-3 cryogenic proof pressure test was successfully completed. To reduce spacecraft loads during S-IC F-1 engine shutdown, a decision was made to cant the outboard or control engine 2° at T+15 seconds through S-IC cutoff (for SA 503 and subsequent launch vehicles). An F-1 engine had to be replaced because of a fuel leak in the turbopump main fuel seal.

Meanwhile Lunar Module No. 3 arrived at KSC in mid-June and was placed in work stands for initial pre-launch checks. During leak checks, leaks were experienced around some flanges. Steps were being taken to solve this problem.

#### **Development and Test**

The Apollo space vehicle design was rapidly approaching maturity as modifications resulting from the Apollo 204 accident review and from the initial flight of the Saturn V launch vehicle were being incorporated and confirmed through test. Significant test and required modification activity was underway on spacecraft structure and launch vehicle first stage propulsion. This work was primarily aimed at controlling longitudinal oscillations of the vehicle.

*Command and Service Module.*—The extensive design and test procedure changes resulting from the Apollo 204 accident continued to be implemented. The additional changes and related retesting further delayed the Apollo Program; the Spacecraft continued to be the pacing item in the program.

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The command and service module design was verified by thermal/vacuum testing with no major changes required prior to manned flight. The command and service module inflammability tests, initiated following the AS-204 accident, were completed. From these tests, the Agency decided that a safe spacecraft atmosphere could be 95 percent oxygen at 6.2 psia or 60 percent oxygen/40 percent nitrogen at 16.2 psia. Spacecraft launch atmosphere will be 60/40 at 16.2 psia. After lift-off the environment would gradually change to almost 100 percent oxygen at 5.0 psia at or near orbit insertion.

Acoustic and vibration tests were conducted to evaluate the ability of a crewman to perform tasks in a Saturn V simulated launch environment. Test vehicle CSM-105/AV was used for these tests. A successful manned low-frequency vibration test with Astronaut Gordon Cooper completed the series of tests.

Qualification of the two drogue/three main parachute configured Earth Landing System (ELS) was nearing completion. Water impact testing designed to demonstrate the ability of the command module to land in water, even though landing velocities were increased slightly because of weight increases, were progressing satisfactorily. And the CSM structural test program was nearing completion.

To validate the Block II Service Module propulsion system, three static firings were conducted using SM 102. One 10-second and two 60-second firings were successfully accomplished. Based on the satisfactory results of these firings, NASA concluded that a static firing of SM-101, to be used in Apollo 7, would not be required.

Manufacturing of Command and Service Modules 103 and 104 was completed. Both spacecraft were well into factory checkout by the end of June. CSM-103 was to be delivered to Kennedy Space Center in August for the second manned Block II mission. CSM 106 should be undergoing factory checkout in mid-July. The remaining flight vehicles were in various stages of manufacture. Command and Service Modules 104 and 106 should be delivered to Kennedy Space Center in the second half of 1968. Manufacturing completion rates were averaging one CSM every two months. (Fig. 1-5.)

*Lunar Module*—During the first half of 1968 several major milestones were accomplished in the lunar module (LM) program. At the beginning of the year Lunar Test Article 8 was in vacuum chamber B at MSC undergoing thermal/vacuum tests constraining the LM-3 mission (the first manned LM flight). The structural test article, LTA-3, successfully completed man-rating drop tests at the contractor's facility. Subsequently, it was transported to MSC for use in the

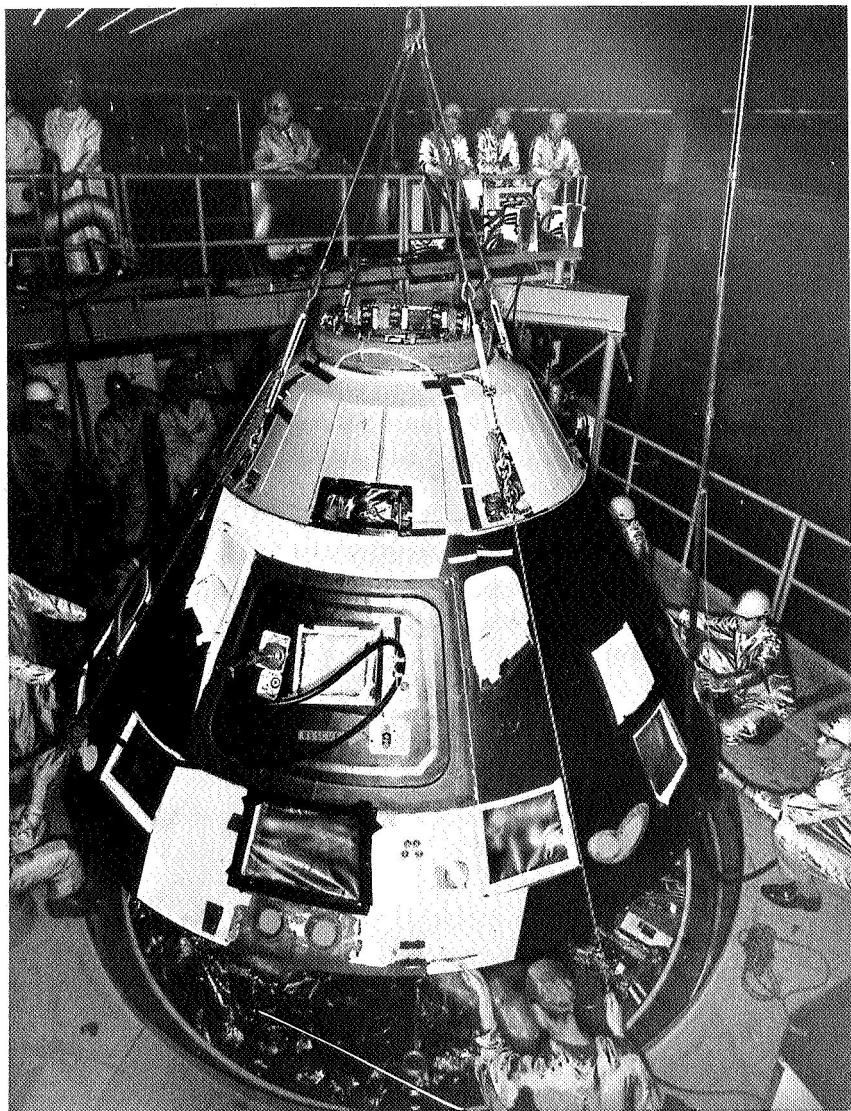


Figure 1-5. Command Module 103 during de-stacking.

space vehicle oscillation test program. Flammability tests of the article designed for that purpose, the M-6 modified to the LM-3 configuration, were started in June at MSC. They were to be completed in July.

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Factory checkout of LM-2 originally scheduled for the second unmanned mission, was completed. However, as a result of the successful Apollo 5 mission, NASA concluded that a second unmanned lunar module mission would not be required. Future plans were to use LM-2 in the spacecraft ground test program.

Manufacturing and factory checkout of LM-3 were completed in June. It was delivered to KSC where it was undergoing pre-launch checkout for a manned Saturn V mission.

Because of continuing increases in the weight of the LM, several weight-saving changes in structure and in vehicle consumables were made. The weight control program is to continue, although it appeared that this problem was being satisfactorily coped with.

*Apollo Lunar Surface Experiments Package.*—Apollo Lunar Surface Experiments Package (ALSEP) efforts included testing the qualification model, fabricating the flight articles and testing of the first unit.

*Software.*—Schedule problems in flight computer programs were brought under control during this period. The final Command Module computer program for the Apollo 7 flight was released for memory module manufacture in February, and subsequent testing in mission simulation found no major problems. The preliminary Lunar Module computer program for the earth orbital mission was released for memory module manufacture on schedule in April. Final release was scheduled for July.

*Saturn IB.*—One Saturn IB (SA-204) was launched and pre-launch preparations were initiated on SA-205.

At the end of June, five Saturn IB first stages, 206 through 210, were in storage. The remaining two stages (211 and 212) were in final checkout prior to being placed in storage. Three static firing operations were conducted with the 211 stage. The first ended prematurely because a LOX seal in the turbopump failed. After a change was made in the LOX seal drain interlock system, the other two static firings were successfully completed.

*Saturn V.*—One Saturn V (SA-502) was launched and pre-launch preparations were underway on SA-503.

The S-IC-4 first stage was removed from storage in late December 1967 for modification and recheck prior to delivery to KSC in August. S-IC-5 was removed from storage in early February for modifications and post static checkout. Delivery was scheduled for the latter half of 1968. S-IC-6 was delivered to MTF in February for the static firing acceptance test. S-IC-7 was removed from storage for modification

prior to being shipped to MTF for acceptance testing. S-IC-8 through 13 were in various stages of assembly, and assembly of S-IC-14 was begun.

The S-II second light weight structure passed a significant milestone in March when the S-II-4 flight article successfully completed the cryogenic proof pressure tests. This test verified the structure under full cryogenic conditions and at pressures above the maximum expected during flight.

S-II-4 stage also successfully completed a captive firing acceptance test in February, and, after the cryogenic proof pressure test, it was delivered to KSC. S-II-5 and 6 were delivered to MTF for cryogenic proof pressure tests and captive firing acceptance testing. Stages 7 through 9 were in various phases of systems installation and factory checkout. The remaining stages were in fabrication and assembly.

Saturn V third stages S-IVB-4 through 7 were in periods of storage and modification during the first half of 1968. S-IVB-8 completed engine installation and system checkout and was placed in storage. S-IVB-9 through 13 were in various stages of structural fabrication and

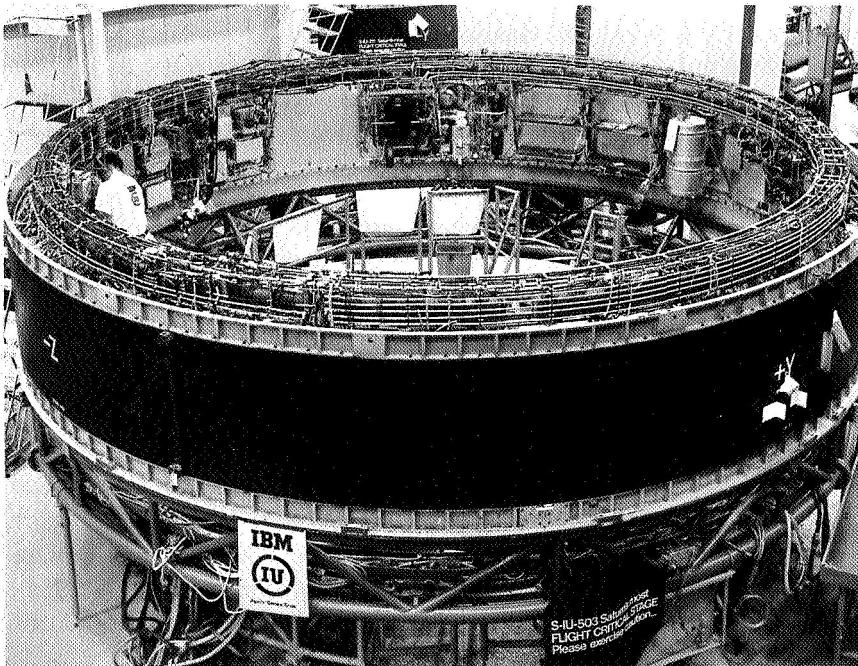


Figure 1-6. Instrument Unit (S-IU-503).

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assembly. Assembly of the final two stages is scheduled to start in the second half of 1968.

*Instrument Unit.*—Instrument unit S-IU-503 was delivered to KSC. (Fig. 1-6.) S-IU-504 was being modified and retested. S-IU-505 through 508 were in various stages of fabrication and assembly; the remaining stages were not yet in manufacturing.

### Technical Problems

The post-flight analysis of the Apollo 6 mission disclosed three technical problems requiring immediate solution. The three principal problems were: longitudinal oscillations in the launch vehicle in the range of 3 c.p.s. which produced a "POGO" effect and unacceptable G-loadings on the spacecraft; malfunction of the J-2 Engine Augmented Spark Igniter fueling lines resulting in early shutdown of one S-II J-2 Engine and failure of the J-2 to restart in the S-IVB; and a structural failure in the spacecraft LM adapter (SLA) at approximately T+133 seconds.

*Launch Vehicle Longitudinal Oscillation (POGO).*—In the latter portion of first stage boost operation, AS-502 encountered longitudinal oscillations in the launch vehicle in the range of 5 c.p.s. which produced a POGO effect and unacceptable G-loadings on the spacecraft. The vibration stemmed from oscillations related, in turn, to normal engine thrust variations. To "detune" these oscillations, NASA considered several candidate solutions of which two were committed to engine test. In the first, gaseous helium is introduced directly into the liquid oxygen feed system of the five F-1 engines. In the second, such helium is introduced into an accumulator in the LOX feedline. Single engine firings gave evidence that the latter method would be more effective. Testing and analysis confirmed adequate stability margin at all structural modes with an accumulator incorporated in the S-IC stage LOX feedlines. The accumulator fix was accomplished by filling the existing prevalve cavity with helium. The fix was simple and failsafe, requiring a minimal addition of plumbing to provide helium to the prevalves from existing on-board helium supply. The hardware for the POGO fix has been installed on Apollo 8 (AS-503) and approved for subsequent launch vehicles.

*J-2 Engine Augmented Spark Igniter.*—At 260 and 318.9 seconds into the Apollo 6 mission during S-II stage powered flight, J-2 Engine No. 2 experienced unexplained performance shifts and premature shutdown occurred at 412.31 seconds on this engine.

The cause of this anomaly has been conclusively demonstrated. The cause, a failure in the fuel line feeding the J-2 Augmented Spark Igniter has been duplicated in engine testing and the specific cause for the failure identified as a flow induced vibration in the flexible bellows section of the line. This phenomenon had been masked in previous ground testing because of the vibration damping effects of liquid air on the exterior of the bellows. Vacuum tests have induced rapid failure in these bellows at peak flow rates. The ASI lines were redesigned to eliminate the bellows sections and a qualification test program verified the fix, including engine tests at AEDC at altitude conditions, and stage testing of both S-II and S-IVB. In addition, fluid lines throughout the space vehicle have been checked to insure that similar problem inducing conditions do not exist elsewhere in the flight system.

*Spacecraft-LM Adapter (SLA).*—At 133 seconds into the Apollo 6 flight, mission photography visibly showed anomalous behavior in the SLA area. This correlated with abrupt reading changes in Spacecraft, IU and S-IVB instrumentation. The anomaly was identified as pieces of the SLA shell separating from the space vehicle. The SLA structure had suffered some local failure but had sustained flight loads for the remainder of the mission.

The SLA anomaly analysis determined that the local failure of the panel was most likely to have resulted from a localized area of debonding. Tests and analyses have established that earlier concerns of shell instability were not the cause of the anomaly. A rigorous program of ultrasonic inspection, tension/shear pull tests, and venting of the core through inner face sheet has been applied to all SLA's. In addition, the 503 SLA has been insulated with cork to provide additional protection against heat.

#### **Constraints and Problems**

The thermal vacuum test CSM (2TV-1) was subjected to manned testing in support of CSM 101 in June 1968. The test vehicle was being prepared for other testing in support of CSM 103. (Fig. 1-7.)

The Agency scheduled for July the final Boilerplate Spacecraft parachute qualification test, a high altitude abort simulation with one drogue/riser development test to demonstrate ultimate loads.

CM 102 parachute loads testing in support of CSM 101 was scheduled for completion in July. Two additional water impact drop tests were also being planned for July. The test vehicles for the "short

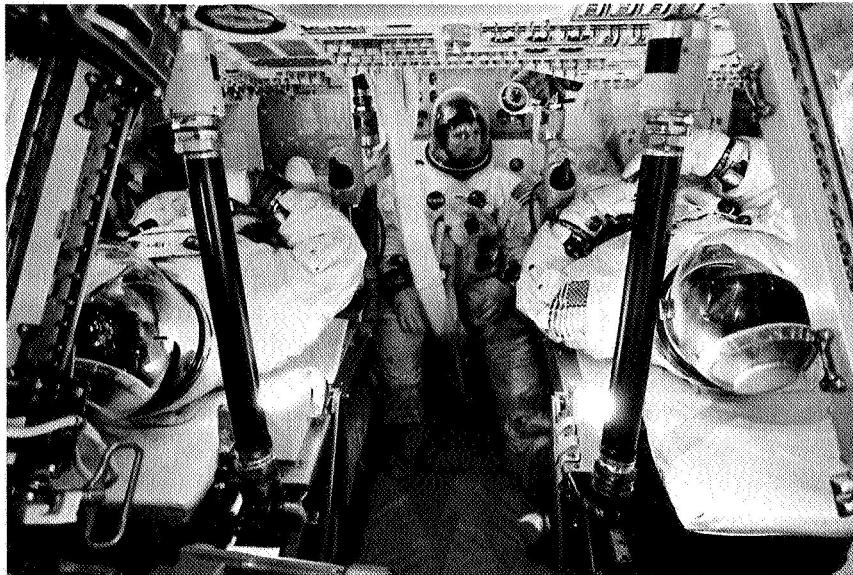


Figure 1-7. Interior View of Apollo 2TV-1 (CSM).

stack" static and dynamic tests were assembled and checkout was in progress. The docked modal tests were planned for August. "One engine out" test preparations were to begin in July.

Tests of Lunar Module Test Article (LTA) 8 constraining LM-3 were completed. The LTA-8 vehicle was being modified to the LM-5 configuration for similar tests.

Flammability tests constraining LM-3 were scheduled for completion in July 1968. These additional tests were required because of the differences in the cabin area of LM-3 and LM-2.

CSM and LM production continued to pace the delivery of flight vehicles. Spacecraft changes, in addition to those made after the Apollo 204 accident, contributed to delays. Production schedules were based on a three-shift operation, seven days per week with little or no allowance for trouble shooting and changes. All changes continued to be placed under close scrutiny by the MSC Configuration Control Board.

### Apollo Applications

The Apollo Applications Program (AAP) continued to focus on the use of capabilities developed in the Apollo Program to expand man's knowledge of space.

The AAP objectives remain as described in the *18th Semiannual Report* but financial restraints have emphasized the need for efficient use of resources. Since first proposed, AAP planning has involved

long duration earth orbital missions for scientific, technological, medical, and human factors purposes; for solar astronomy studies; and for extended lunar exploration missions.

#### AAP Objectives

Long duration space flights will involve the use of the unique capabilities of man as a participant in space flight activities. Habitability, biomedical, behavioral and work effectiveness experiments will be performed to determine how man is able to function in the environment of space. Systems and subsystems of space vehicles will also be evaluated for long duration flights in a series of steps of increasing duration, complexity and capability.

The first step in applying manned space systems to the achievement of major scientific objectives will be in solar astronomy. Later, both earth and astronomical observations will also be performed.

Experiments will be performed to study the useful application of space systems to meteorology, earth resources and communications.

#### AAP Management

Financial restrictions have made it impossible to proceed with Saturn IB Apollo Applications launches concurrently with the Apollo Program flights in 1968 and 1969. As a result, the AAP was delayed and the number of flights was reduced. However, the operational content of the early portion of the program remained substantially the same.

During the report period, because of uncertainties regarding Congressional action, the AAP initiated a "holding action." This holding action resulted in additional slippages in schedules and deferment of certain management actions. The concept of an Apollo Applications "Core Program" developed because of the financial constraints. Planning was underway around a "core" of a limited number of launches (AAP-1 through AAP-6, including AAP-3A). The core program includes a Saturn I Workshop dual launch mission, a Revisit single launch mission, a Solar Astronomy dual launch mission, and a backup Saturn I Workshop dual launch mission. The initial AAP flight, the Saturn I Workshop, was deferred until late 1970. The other "core program" launches were correspondingly delayed. The flexibility, however, remains to expand the technical efforts beyond the "core program" when adequate funding becomes available and additional scientific, technological, and operational endeavors are identified.

#### Program Status

AAP missions continued to be based on the concept of the maximum use of existing hardware, launch vehicles, and spacecraft developed for the Apollo Program. In addition, concepts of revisit, reuse,

supply, and repair of equipment in orbit are to be tested and evaluated from an economic standpoint. AAP flight mission planning is focused on earth orbital missions using the Saturn IB launch vehicle.

*Saturn I Workshop Mission.*—Initial operations with the Saturn I Workshop are planned in late 1970. Crew living quarters and experiment operations spaces are set up inside the empty hydrogen tank of a spent S-IVB stage after its actual use as a launch vehicle second stage. This workshop then serves as living and working quarters for the crew. (Fig. 1-8.)

The Saturn I Workshop mission requires the launch of two Saturn IB vehicles. An unmanned flight, consisting of a Saturn IB with a modified S-IVB stage, an Airlock Module and a Docking Adapter, will be launched first. This launch is designated AAP-1. The manned Apollo Command Module with its Service Module will rendezvous and dock with the S-IVB stage of the first flight. The hydrogen tank of the unmanneed S-IVB stage will have been modified so that it can be made safe for occupancy and used for living and working quarters.

The experiments planned on this mission are chiefly devoted to the study of men in space over extended periods of time. Habitability experiments to be performed will include crew quarters evaluation, food and food preparation, personal hygiene provisions, space suits evaluation, and mobility devices. Extensive medical evaluations of the effects of long duration space flight on the crew will be made. The

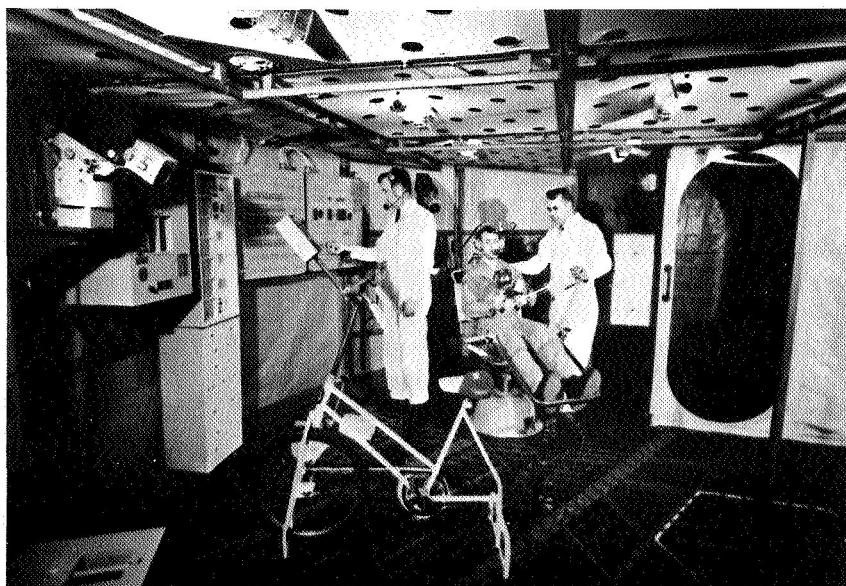


Figure 1-8. Main room of Saturn I workshop.

ability of the crew to move and assemble equipment will be studied, and their performance of large scale as well as laboratory tasks will be evaluated. This mission is open-ended with consumables on-board sufficient for a 28-day mission.

*Workshop Revisit Mission.*—The Workshop Revisit mission uses a single Saturn IB launch of a three-man Command and Service Module to rendezvous and dock with the Saturn I Workshop which will be stored in orbit at the completion of the previous mission. This mission is designated AAP-3A. Its planned duration of up to 56 days is the next step in the progressive extension of mission length to test and evaluate the ability of both man and equipment to function effectively for long periods of time in space. One of the principal purposes of this mission will be to conduct a comprehensive medical test program on the crew.

*Solar Astronomy Mission.*—The third mission, planned for 1971, uses the Saturn I Workshop as a base of operation for a Manned Solar Observatory. One Saturn IB will launch a three-man Command and Service Module with consumables sufficient for a 56-day mission. This flight is designated AAP-3. A second Saturn IB will launch the unmanned Apollo Telescope Mount with its payload of solar instruments. This flight is designated AAP-4. After the Command and Service Module and Apollo Telescope Mount each rendezvous and dock with the Workshop, the crew activates the Apollo Telescope Mount and Saturn I Workshop and begins the operational phase of the missions. (Fig. 1-9.)

Using high resolution solar telescopes and spectrographs, the crew will operate the system to observe and record dynamic phenomena on the surface and in the corona of the sun. This mission will be the first flight test of equipment and operating concepts for future manned and man-tended astronomical observatories.

*Backup Saturn I Workshop.*—This backup mission in the AAP “core program” consists of the dual launch of a three-man CSM spacecraft (AAP-5) with a backup Saturn I Workshop (AAP-6). It is to be flown if for some reason the initial Saturn I Workshop mission is unsuccessful.

#### **Hardware**

The AAP continued to move forward in developing and modifying major hardware items, and in developing prototypes of experiment hardware.

*Saturn I Workshop.*—The design of the S-IVB modifications, which will convert the spent stage into a workshop, was continuing at the contractor's facility at Huntington Beach, Calif. In January, the mockup of the Saturn I workshop was shipped to Marshall Space

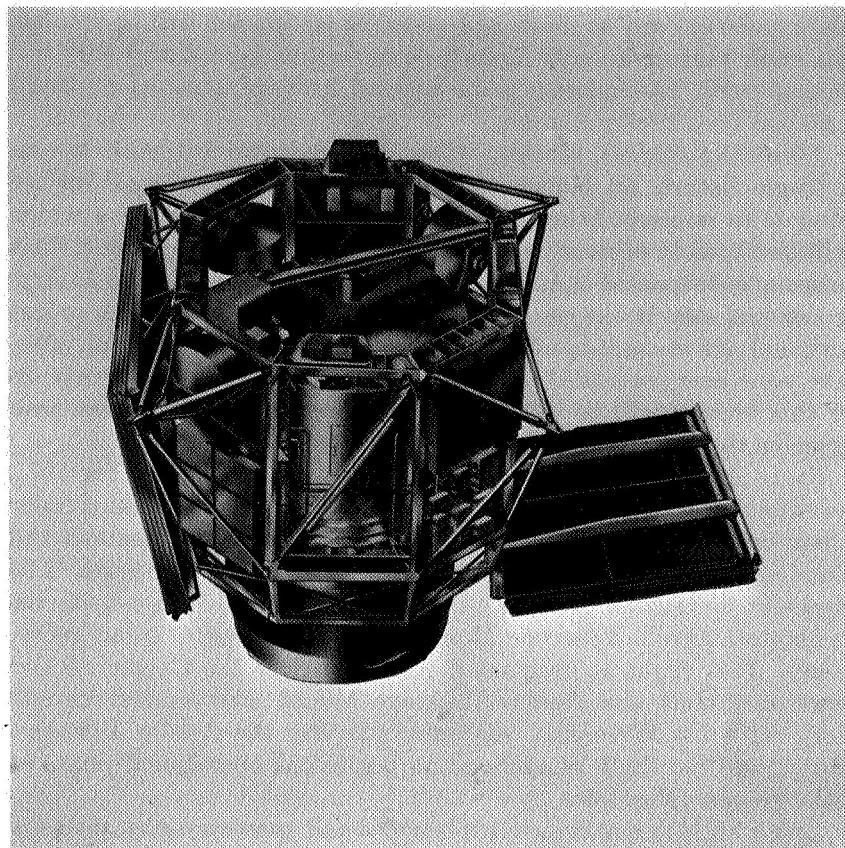


Figure 1-9. Apollo Telescope Mount.

Flight Center (MSFC), and a crew-walk-through inspection was conducted. A preliminary design review was held in March at MSFC to supplement the May 1967 design review; this review resulted in approval of the spent stage preliminary design. The preliminary requirements review on the Workshop Attitude Control System was held in June at MSFC and an operational readiness inspection was conducted of a large neutral buoyancy test facility to be used at Marshall for astronaut training.

*Airlock Module.*—The design of the Airlock Module was continuing at the contractor's facility in St. Louis, Missouri. The static test article was completed; it will be mated with the Multiple Docking Adapter at MSFC in the latter half of this year, and static and dynamic development tests will be initiated. Neutral buoyancy evaluation of the Airlock design continued at the Manned Spacecraft Center. Design and development of the Airlock's critical subsystems also continued.

The configuration of the Airlock Module consists of a tunnel and truss structure forming the central "engine room" of the cluster. It incorporates the electric power conditioning, storage, and distribution system for the entire cluster; the central Environmental Control System; and the central command and instrumentation center for the orbital workshop. (Fig. 1-10.)

*Multiple Docking Adapter.*—The Multiple Docking Adapter (MDA) was being developed and fabricated in-house by NASA at MSFC. The preliminary design review was held on this item in January. In April, a task force was established to determine the feasibility of conducting key medical experiments within 24 hours after launch in the MDA and prior to activation of the spent stage. Studies established the feasibility of this proposal without a major change of the MDA design. Early medical experimentation was incorporated in the new mission profile. (Fig. 1-11.)

*Apollo Telescope Mount.*—Work on the Apollo Telescope Mount (ATM) was continuing at MSFC. In January, the preliminary requirements review was held on the ATM Pointing Control System. Similar reviews of the remaining ATM subsystems were being planned. Two scientist-astronauts took part in a simulated operation of the ATM during May, using the computer driven ATM simulator at MSFC.

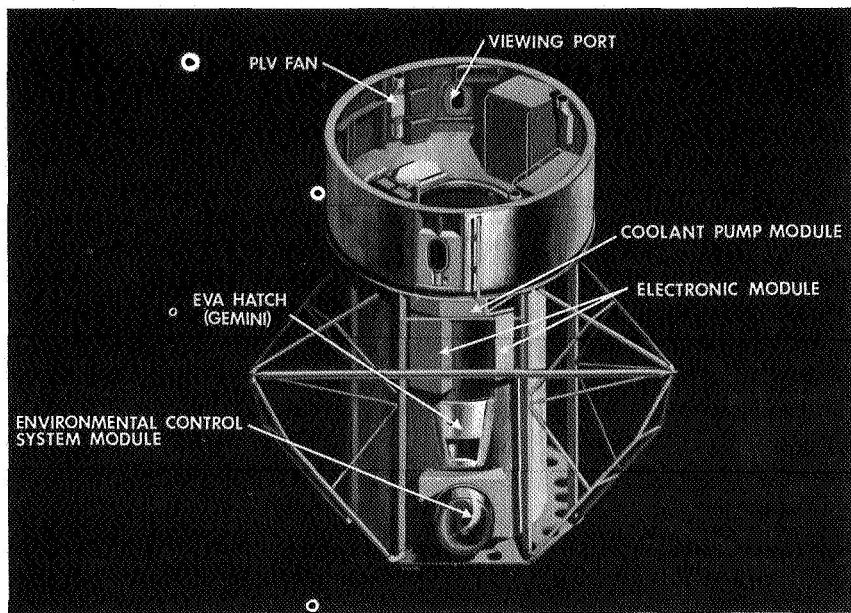


Figure 1-10. Concept of Airlock Module.

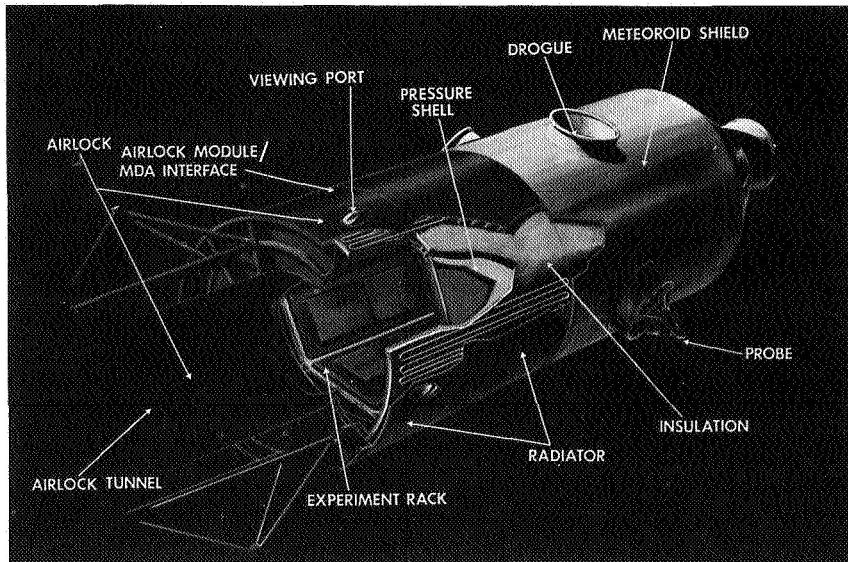


Figure 1-11. Concept of Multiple Docking Adapter.

Five experiments are currently planned for the Apollo Telescope Mount (ATM). These were being fabricated by the High Altitude Observatory, Boulder, Colorado; the Naval Research Laboratory (NRL), Washington, D.C.; the American Science and Engineering Company, Cambridge, Massachusetts; the Goddard Space Flight Center (GSFC), Greenbelt, Maryland; and the Harvard College Observatory, Cambridge, Massachusetts.

*Lunar Module.*—The earth orbital missions for the AAP employ the ascent stage of the Apollo Lunar Module (LM-A). The changes required to modify this stage for AAP use were being designed at the contractor's facility in Bethpage, Long Island, New York.

In May, the preliminary requirements review meeting was held. An astronaut-walk-through exercise was performed on a mockup model of the Lunar Module. Final definition work will result in a preliminary design review, planned for late September (1968).

*Command and Service Modules.*—To enable man to exist in space for extended durations, up to 56 days, it is necessary to make certain modifications to the basic Apollo Command Module and Service Module. Preliminary design work was being performed to define what these modifications should be. These efforts were being concentrated in the areas of trade-off studies and definition.

*Launch Vehicles.*—Launch vehicles procurement is under the cognizance of MSFC. The initial flight missions of the AAP will use those Saturn IB Launch Vehicles procured within the Apollo Program but not needed to accomplish the manned lunar landing. The current AAP mission plan assumes availability of Apollo Saturn IB vehicles 206 through 212 for initial AAP use.

### Advanced Manned Missions

The Advanced Manned Missions Program continued studying three major areas during this reporting period: Future Space Stations, Space Transportation Systems, and Space Safety.

Previous Space Station Studies examined concepts that used the S-IVB stage structure and/or envelope and required the full capability of the Saturn V vehicle for launch. These Saturn V stations represented a full integrated "all up" design approach with experiments and equipment being launched with the station along with most of the consumables required for the operational lifetime of the station. While this approach has some attractive features, it is highly inflexible from both management and mission operations viewpoints. The need for a concept that could provide a high degree of program and mission flexibility led to the conduct of three independent studies, by the Langley Research Center, the Manned Spacecraft Center, and the Marshall Space Flight Center during May and June 1968. These efforts yielded several future space station concepts which are better suited to the prevailing planning atmosphere than alternatives previously available for management consideration.

Certain desirable characteristics were formulated as general guidelines for the studies. The space station should provide for a nominal crew size of six with growth capability to nine men; it should, however, be operational with a crew of three. It should have a two-year operational lifetime. Subsystems should be designed, and components packaged, to facilitate maintenance, repair, and onboard checkout. The station should possess a high degree of mission and operational flexibility and provide for the conduct of useful science and applications programs including the demonstration of man's contribution. The system should be potentially capable of becoming operational in the mid-1970's.

Three concepts evolving from the studies were selected for more detailed effort. All possess the desired characteristics. In addition, they are similar in their ability to operate with separately launched payload modules and in their ability to operate with a logistics system based on either a Gemini derivative spacecraft or the Apollo Command and Service Modules.

One concept is made up of one or more independent three to five man stations; each consists of a 22-foot diameter cylinder having the capability to dock with another station in orbit, or to be stacked together with another station and launched as a unit.

The second concept is a highly integrated station which could house a crew of three to nine men; it has a pressurized hangar/test compartment which serves for crew and cargo transfer as well as for a work area.

The third concept evolving from the studies consists of various combinations of subsystems, crew, logistics and experiment modules. Repeated launchings of manned and/or unmanned modules can build up an orbital station responsive to a variety of mission requirements. More detailed design and definition of these alternatives was being planned as part of the continuing effort to select the best approach to advance manned earth orbiting flight beyond the Saturn I Workshop.

Manned Space Flight transportation systems studies have emphasized inhouse work involving Headquarters, the Centers, and unfunded contractor participation. These studies have produced certain specific results. The Saturn V launch vehicle and its two-stage derivatives—the S-IC + S-II, and the S-IC + S-IVB—offer a readily available, flexible and economical family of man-rated launch systems covering a broad range of missions and payloads. Considering the total cost to the Government and the projected launch rates, NASA believes the Saturn V system and its two-stage derivatives provide an economical launch vehicle stable. They can be used not only with the Apollo spacecraft systems but also with new or improved payload and flight systems while exploiting ground launch facilities already in existence.

Techniques for reducing space transportation costs of existing launch vehicle systems and derivative configurations were being identified. It was clear, however, that the viability and success of long duration orbital laboratories and space stations will be critically dependent on the availability of a more efficient and flexible round-trip transportation system.

Studies were initiated to develop space safety design criteria. These studies will provide guidance to future space station designers as to design features and practices which may affect astronaut safety. The criteria were being developed with respect to routine operational tasks, experiment activity, spacecraft control, materiel handling, and onboard systems maintenance. Astronaut activities, and possible hazards associated with them (both internal and external to the spacecraft) are being considered.

Previous studies established the desirability of providing low earth orbital escape or rescue systems. Escape vehicle concept studies investigated alternate designs for 3-man escape vehicles applicable to low earth orbit. Several ballistic shapes were evaluated in the course of the studies; these include spheres, modified spheres, and a number of conical shapes. It is the purpose of a recently initiated study to develop a concept, or concepts, which will be light enough and uncomplicated enough to provide astronaut safety in the event of a major space station failure. The information developed in the course of this study, together with previously developed data, will provide guidance in selecting an escape/rescue system for possible use with future low earth orbital space stations.

### **Mission Operations**

The Agency's manned space flight mission operations activities were concerned with flight crew operations, support requirements, mission control systems, launch information systems, operational communications, and the Huntsville Operational Support Center.

#### **Flight Crew Operations**

The flight crews for the first three manned Apollo flights continued in their training programs. Each crew took part in the development testing of its spacecraft. By the end of June, the crew for AS-205 (first launch) was essentially in residence at Kennedy Space Center.

The scientist-astronauts selected for training in 1967 entered flight training at various USAF bases. One astronaut, finding that he did not care for flying, resigned. One of the pilot astronauts was grounded for physical reasons and has returned to his parent service for treatment.

The first lunar landing training vehicle was placed into full scale training operations early in 1968. After 50 training flights, the vehicle crashed and was destroyed. The pilot, astronaut Neil Armstrong, ejected safely and received only minor injuries. An accident investigation board was reviewing the circumstances surrounding the accident at the end of June.

At the time of the accident, the vehicle had flown almost 300 flights during the research program at the Flight Research Center and the training program at the Manned Spacecraft Center.

Two other vehicles for training purposes only were well on their way through ground test preparatory to flight test.

#### **Operations Support Requirements**

Satisfactory operations support of Apollo 5 and 6 was achieved through the Requirements/Support Documentation System.

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NASA continued its associate membership on the DOD Inter-Range Documentation Group and, working closely with it, was helping to develop a Unified Documentation System (UDS). On January 1, the first two documents of this system became effective.

Continued scrutiny of support requirements enabled NASA to achieve cost reductions. Some of the more major items deleted were the Azusa/Glotrac System and the MSF requirement for the reentry ship Watertown.

### **Mission Control Systems (MSC)**

In the first half of 1968, the Mission Control Center (MCC) completed program development, pre-mission simulation and testing, and provided real time flight control for Apollo 5 and 6. Program development and simulation training were initiated for Apollo 7, the first manned Apollo, and Apollo 8, the first manned Apollo Saturn V mission.

The electronic computer switchover and restart hardware for improved system reliability and computer back-up was installed and tested. A reconfiguration documentation system was also put into use to reduce MCC turnaround time between missions.

Procurement specifications, using the developmental prototype Digital Television Display System as a basis, were prepared and a Request For Proposal (RFP) issued for the first increment of a much improved computer-driven display system. Studies were initiated relevant to the mission control hardware for the Apollo Lunar Surface Experiment Package (ALSEP), modifications to the MCC voice switching system for quicker reconfiguration, and a more satisfactory hard-copy recording system.

The Apollo Spacecraft Communication System and ground station equipment were tested for compatibility and performance. An operationally-equipped Apollo Range Instrumentation Aircraft (A/RIA), a major communication system used during translunar injection, was tested and evaluated. Major activities remaining are Lunar Module detailed testing and combined space vehicle communication testing.

### **Launch Information Systems (KSC)**

Launch Information Systems are the meteorological, acoustic, hazard monitoring, lightning warning, telemetry, display, data recording, and computing systems used during pre-flight, count-down, and launch of space vehicles at KSC.

During the period, these systems very successfully supported the Apollo 5 and 6 launches from Launch Complexes 37 and 39, respectively; they also supported the initial phases of Apollo 7 prelaunch testing.

At Complex 39, testing continued on Launch Information Systems associated with Firing Room 3, Mobile Launcher 3, Vehicle Assembly Building Bay 2, and Launch Pad B. These facilities will be needed in support of future Apollo Saturn V vehicles.

#### **Operational Communications (KSC)**

Launch Complex 34 operational intercommunication system (OIS-A) was modified to a four-wire system. The modified system was used in support of the initial phases of the Apollo 7 launch vehicle checkout. This is one of the improvements made to the launch complex following the Apollo accident investigation.

The Communications Distribution and Switching Center was augmented to include a central communications status monitoring capability. Audio and TV recorders were also installed to provide documentation of OIS and operational television during Apollo vehicle checkout and launch operations.

The control center of the LC-39 operational television system malfunctioned during Apollo 4; subsequently, it was replaced. The new equipment was installed and supported the Apollo 6 launch in April.

#### **Huntsville Operations Support Center (MSFC)**

The Huntsville Operations Support Center (HOSC), manned by MSFC technical personnel, provides real-time consultative support to KSC during pre-launch and launch operations and to the Mission Control Center at MSC during flight operations. The newly augmented HOSC was successfully used to support Apollo 5 and 6. Conversion of the old TV display system to an all-digital TV display system was largely completed. The new system will improve the reliability and quality of the support provided by the HOSC.

### **Supporting Facilities**

Manned space flight supporting facilities continued to be activated as planned. The key facilities and related equipment required for the manned lunar landing program were in being and were supporting the test, launch, and operational phase of the Apollo Program. The efficiency of these facilities was again successfully demonstrated with the Apollo 6 mission. Launch preparations and operations were carried out at the Kennedy Space Center's Launch Complex 39 facilities, and flight operations were directed from the Manned Spacecraft Center's Mission Control Center. Ground test facilities at the major manned space flight locations continued to support hardware preparations for manned flight. In addition, most of the equipment for the Lunar Receiving Laboratory at MSC was installed.

**Kennedy Space Center**

At Kennedy Space Center, two successful Saturn V launches have taken place, demonstrating that the launch facilities were properly designed and constructed to support these missions. The High Bay No. 2 of the Vehicle Assembly Building, Launch Complex 39, was outfitted on schedule and this facility was being activated. The second addition to the KSC Headquarters Building was completed. The Launch Umbilical Tower No. 3, Launch Area B, was being activated, and a critical power line from the Air Force generating plant at the Cape to the Merritt Island Industrial Area was being constructed. Also being constructed was an emergency egress slide wire system at Complex 39. Automatic Checkout Equipment (ACE) Stations 5 and 6 at the Manned Spacecraft and Operations Building were being activated.

**Manned Spacecraft Center**

At the Manned Spacecraft Center, construction of the Flight Crew Training Facility was completed in April. Within this facility, the Procedure Development Simulator, with associated crew stations, was being installed; it should become operational in the third quarter of 1968.

In the Lunar Receiving Laboratory, installation of equipment was essentially completed and work was underway on conducting shake-down tests, carrying out practice runs, and developing operating procedures. All systems will undergo full simulation in the latter part of the year to show that the facility is fully operational. (Fig. 1-12.)

**Marshall Space Flight Center**

All locations under MSFC cognizance (Michoud Assembly Facility, Mississippi Test Facility), and the various government-owned, contractor-operated industrial facilities that support assembly and test of space vehicles are fully operational. The water pollution control facilities and a centralized fire detection system at MSFC were designed.

**Manned Space Flight Safety**

The Manned Space Flight Safety Office conducted five safety surveys, created a safety plan covering development of future systems, participated in safety reviews, assisted the newly appointed NASA Safety Director in publishing the NASA Safety Manual, and conducted a System Safety Conference for Government and Industry representatives.

A safety survey of the astronaut aviation activity at MSC and surveys of KSC industrial plant, NASA Motivational-Awareness pro-

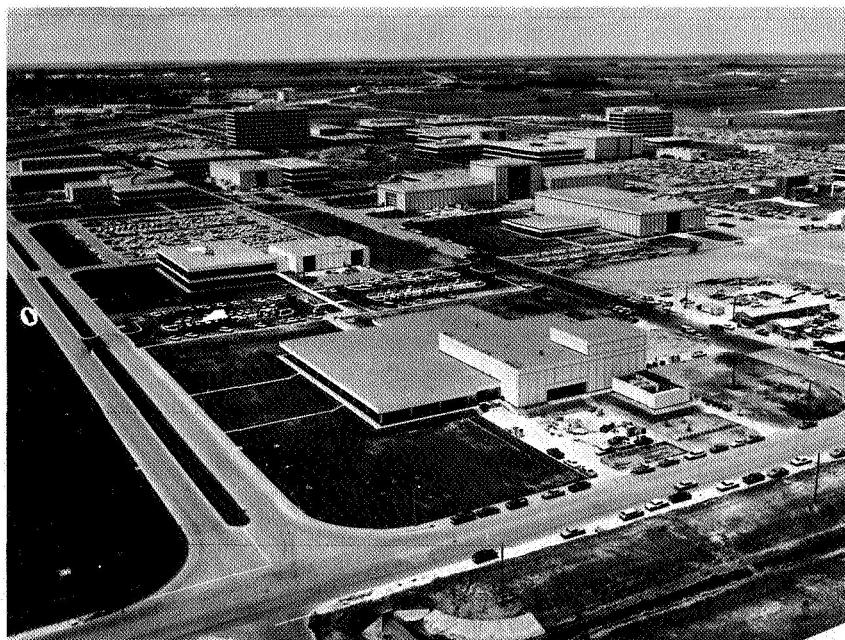


Figure 1-12. MSC, with Lunar Receiving Laboratory in foreground.

grams, and MSFC safety were conducted between January and May. A survey schedule for the next 12 months was prepared and distributed in June covering contractor, center, program, and aviation activities. Another accomplishment during the period was a nationwide NASA-Government-Industry meeting held at Goddard covering system safety.

The Manned Flight Awareness Program was revitalized and given central direction. The resources of this program were also used to support the NASA "Zero Defects on Delivery" Program. The NASA plan for space emergency and rescue systems was refined, coordinated, and forwarded to Congress by the Deputy Administrator for NASA. Studies were initiated to implement the plan.

Studies were initiated on personnel certification requirements, man-rating safety criteria, system safety guidelines, accident investigation guidelines, and emergency systems for advanced programs. The Safety Office was also active in support and assistance to the newly appointed NASA Safety Director in revision and consolidation of comments on the NASA Safety Manual. The results of these studies and support activities will be apparent in the succeeding half year.

### Space Medicine

The final report of the Life Sciences Working Group submitted to top management in April 1968 continued under study. Recommendations of the report to streamline this functional area (redesignated "Aerospace Medicine and Space Biology") of NASA provided for alternative ways of regrouping individual functions; methodologies to be applied for across-the-board management of the research and development responsibilities in Aerospace Medicine and Space Biology; and a uniform system of identification, funding, and review for research, development, and technology in this area.

The Manned Space Flight Network (MSFN) can now retransmit, with a high degree of fidelity, the medical data from remote tracking stations to the Mission Control Center (MCC) at Houston. Physicians monitor the data from this central location. As a result, medical operational support for Apollo requires fewer DOD support personnel than were needed in Gemini (which in turn had been fewer than those used in Mercury).

NASA agreed to provide operational training of an Air Force bioastronautics work force during the Apollo program. Apollo offers a unique opportunity for Air Force Manned Orbital Laboratory (MOL) bioastronautics personnel to gain firsthand experience in managing the vehicle environmental and life support resources, and in assessing crew physiological and medical status during the flight missions. At the same time, the use of MOL personnel during Apollo missions makes available to NASA a group of highly skilled individuals.

The Integrated Medical and Behavioral Laboratory Measurement System (IMBLMS) effort continued. IMBLMS marks the beginning of a system to provide a modularized laboratory in which measurements and experiments may be performed on man or other biological specimens in space flight. It is the first visible step in actually placing a laboratory of this type in space.

NASA efforts to reduce the fire potential in the Apollo spacecraft were reviewed by selected members of the National Research Council (SSB-NRC) together with the Director of Space Medicine. Despite the requirement for nitrogen in the cabin gaseous atmosphere mixture during launch pad operations as a fire prevention method, the consensus was that there is still a medical need for two-gas systems in manned space flight.

A joint Air Force/NASA review of the basis for the gaseous atmospheres used in MOL, Apollo, and AAP highlighted similarities and differences in the breathing atmospheres of the two manned space programs. Future DOD/NASA joint reviews of critical life support

systems were planned, the first to concentrate on waste management systems.

NASA continued to explore the possibility of obtaining information from underseas habitats that might be applicable to manned space flight. *Project Tektite*, a joint program of the U.S. Navy, the Department of Interior, and NASA, in conjunction with an industrial contractor, involves emplacing an underseas habitat on the ocean floor, about 50 feet down, and manning it with a single four-man crew of marine scientists for a 60-day period. The objective of this scientific experiments project is to study marine biology, the physiological effects on man, work proficiency, and the social cohesion of the crew.

The Interagency Committee on Back Contamination reviewed certain testing aspects of the Lunar Receiving Laboratory and made recommendations to NASA regarding quarantine for the lunar program. This involved recommendations and requirements of the Federal regulatory agencies which must be satisfied before the NASA laboratory can be certified.

The NASA *Compendium on Human Responses to the Aerospace Environment*, which went to press during this period, will provide a basic reference for the Aerospace Medical Community.

### Logistics

Significant transportation costs savings were being achieved with the concurrent marine shipment of F-1 engines and S-II stages aboard the USNS Point Barrow from the West Coast to Michoud. Formerly, F-1 engines were transported by aircraft. Additional savings were resulting from the increased use of the Point Barrow for moving S-IC and S-II stages from Michoud to KSC. (Fig. 1-13.)

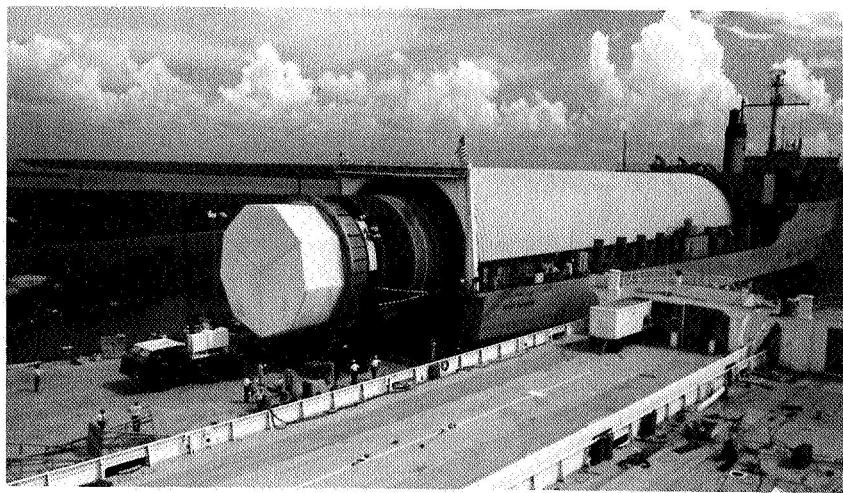
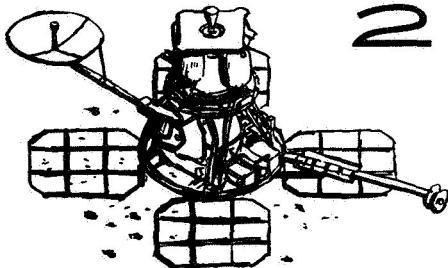


Figure 1-13. Transfer of S-II from *Point Barrow* to *Pearl River Barge*, Michoud.

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Logistics attention was directed to defining and assuring special management of launch critical repair parts of the Apollo program. Initial efforts were fruitful in integrating and computerizing into a single data bank certain selected Apollo contractor material inventories at the Kennedy Space Center. In another area, Apollo-wide standards were issued for preserving, packaging, and handling critical and high cost hardware items to reduce shipping and handling damage.



2

## SCIENTIFIC INVESTIGATIONS IN SPACE

Continuing its comprehensive studies of the space environment and of solar phenomena, NASA launched an Orbiting Geophysical Observatory, Explorer XXXVII, and IRIS, a European Space Research Organization satellite. In addition, Surveyor VII was landed on the moon, and equipment was being installed in a Lunar Receiving Laboratory, built at the MSC as a quarantine facility for astronauts and lunar samples. Finally, a geophysical data transmitting station (the Apollo Lunar Surface Experiments Package) which the astronauts will place on the moon was being developed.

### Physics and Astronomy Programs

#### Orbiting Observatories

On March 4, the fifth Orbiting Geophysical Observatory (fig. 2-1) was launched into an elliptical orbit with an apogee of 92,000 miles. Its mission is to continue the work of OGO-I and OGO-III, and consequently its orbit is similar to theirs. The 1350-pound satellite carries 24 scientific experiments which will enable it to make a comprehensive study of the earth's space environment and its relationship to the sun during a period of maximum solar activity. It spends much of its 68-hour orbital period outside the magnetosphere of the earth so that its instruments can investigate this region as well as the magnetosphere.

Like other spacecraft in this series, OGO-V is a rectangular box with extending booms and two solar cell paddles resembling wings. Stabilized in three axes, it is able to face the earth at all times. Its experiments—developed by six U.S. and four foreign universities, four Government laboratories, and two private companies—are concerned with the trapped radiation belt, the bow shock where the particles of the solar wind meet the earth's magnetic field, the geomagnetic tail of the earth, the solar wind, and cosmic rays. Two electric field experiments and a third using a spark chamber represent major

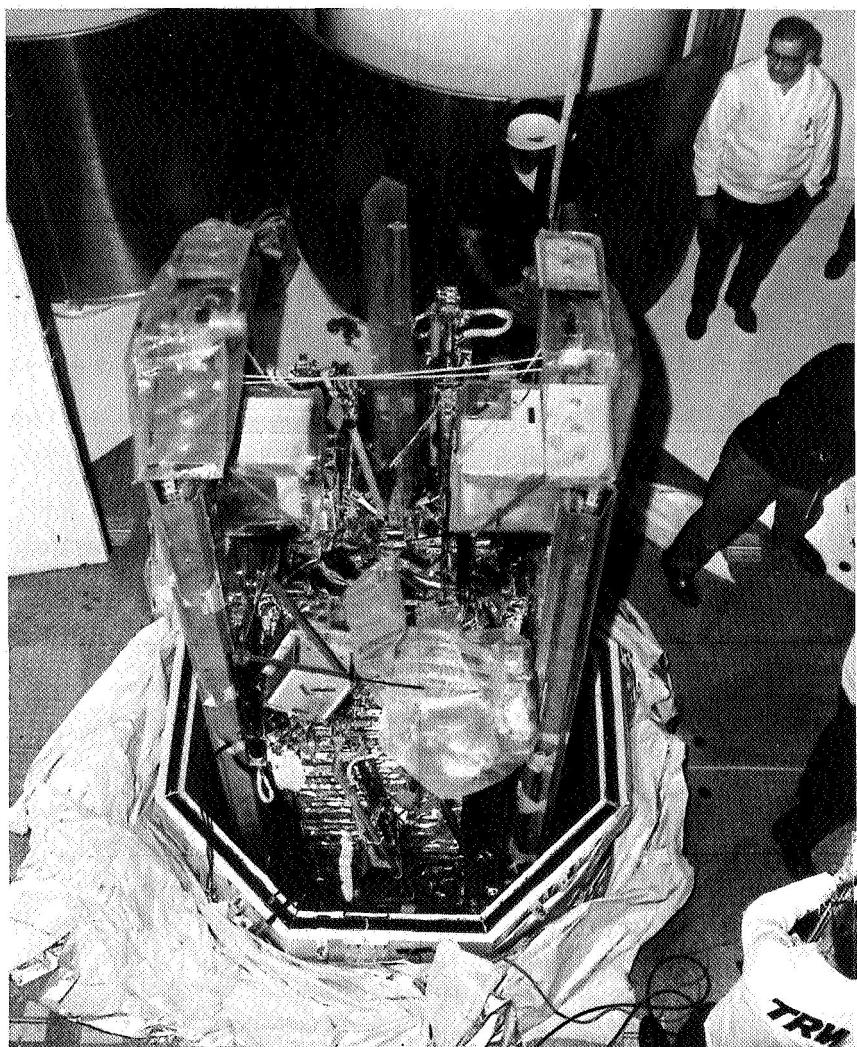


Figure 2-1. OGO-V.

advances in space instrumentation. One electric field experiment was furnished by the Goddard Space Flight Center, the other by an industrial firm. These will supply further data on the bow shock (shock wave) caused by the impingement of the solar wind at high speeds on the magnetic field of the earth. Although observed, the shock wave remains undetermined. The spark chamber, designed by the University of Southampton (England), is used in high energy physics studies of the surface of the earth. This is the first flight of the instrument on a satellite, where it will study gamma radiation in cosmic rays.

After meeting the initial scientific objectives of its mission by mid-June, OGO-V continued to perform well and its further operation was planned. The onboard experiment designed at the University of Paris provided a detailed survey of the hydrogen gas cloud surrounding the earth. The spacecraft also supplied the first detailed measurements of the electric fields at the shock and magnetospheric boundaries, and the first spark chamber observations of gamma rays above the atmosphere. During March, four OGOs operated simultaneously to provide measurements from 68 related experiments located in various positions in space.

#### **Explorer XXXVII**

NASA orbited Explorer XXXVII on March 5, providing the launch vehicle for this joint NASA-Navy project. The Naval Research Laboratory designed and built the 195-pound spin-stabilized satellite. This Explorer, which will continue the Laboratory's solar studies, is a 12-sided body, 30 inches in diameter and 27 inches high (fig. 2-2). Although it was placed in a more elliptical orbit than planned (perigee 324 miles, apogee 545 miles), the spacecraft was meeting all its scientific objectives. The satellite's X-ray photometers, Geiger tubes, photo-multipliers, and solar aspect systems measure and monitor the sun's X-rays and selected solar ultraviolet emissions.

#### **IRIS (ESRO-II)**

The third physics and astronomy satellite launched in this period was the international IRIS (ESRO-II), built by the European Space Research Organization (ESRO) and launched cooperatively on May 16 (ch. 7). IRIS is a spin stabilized cylindrical craft, 19 inches in diameter and 21 inches long, with a protruding 35-inch long central tube. A nearly polar orbit (215 to 680 miles) was chosen to keep the satellite in almost continuous sunlight. IRIS carries five experiments designed by scientists from the Imperial College of London, the University College London, the University of Leicester, and the University of Leeds; an experiment from the University of Utrecht; and an experiment from the Centre d'Études Nucléaires de Saclay. Concerned with cosmic rays and solar X-rays, all experiments were working as designed.

#### **Pioneer**

Pioneer VI, launched in December 1965, continued to transmit data from all of its experiments, as did Pioneer VII, orbited in August 1966. Pioneer VIII (launched in December 1967, *18th Semiannual Report*, p. 45) flew through the earth's magnetic tail at a distance of 1,750,000 miles in January. It found this tail region to be more like a turbulent

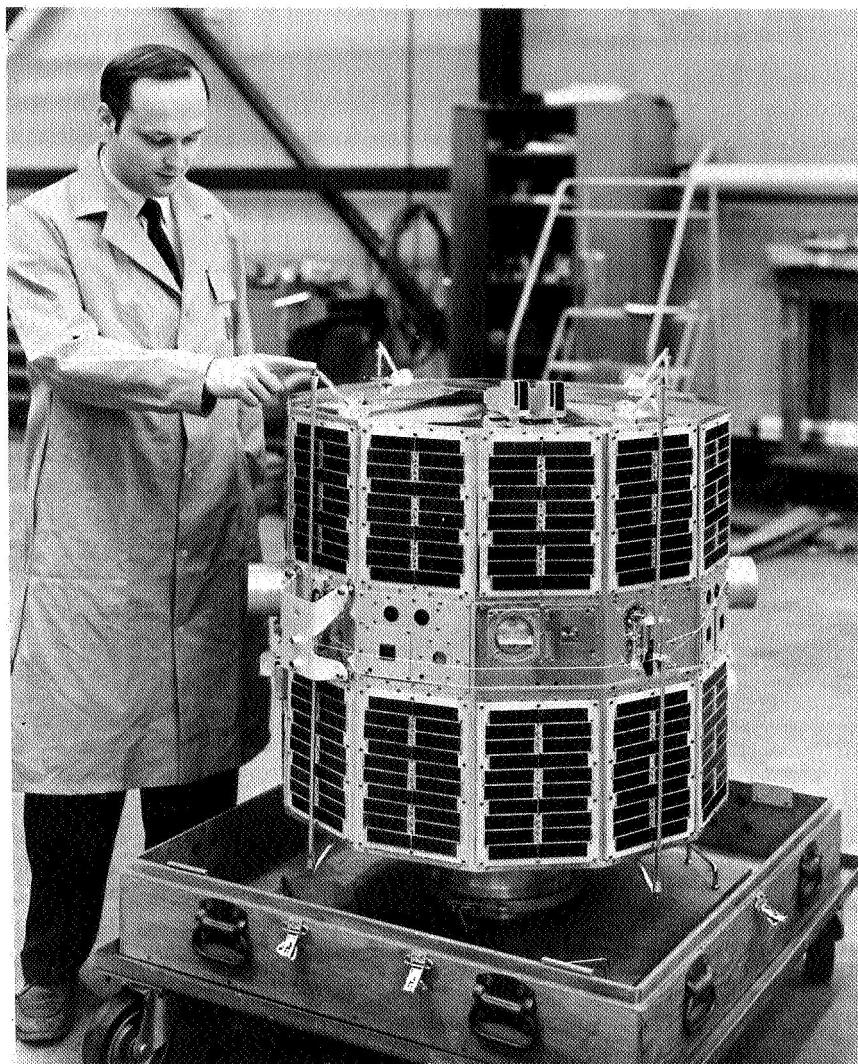


Figure 2-2. A solar X-ray satellite, Explorer XXXVII.

wake, than the smooth cylindrical structure expected at this distance. Knowledge of the tail helps scientists understand the relationship between the magnetic field of the earth and the solar wind. The three Pioneer spacecraft transmit a daily "space weather" report to the Environmental Science Services Administration and the North American Air Defense Command (NORAD) to assist in forecasting.

The next Pioneer launch is scheduled for November. The spacecraft was assembled and completed earth test phases satisfactorily. It will

carry instruments similar to those on Pioneers VI, VII, and VIII and will complement their observations with studies of magnetic fields, plasma, and high energy particles.

#### **Earlier Spacecraft**

In May, OGO-IV (launched in July 1967) completed ten months of successful operation. The spacecraft is in a low, nearly polar orbit (250 to 560 miles) where it studies the relationships between solar phenomena and solar radiations and the earth's environment during a period of increasing activity of the sun.

Explorer XXXIV (orbited in May 1967 with a planned lifetime of a year) survived a threat to its continued operation this May when it passed into earth's shadow for four hours. While there, the satellite's temperature fell far below that for which its systems and subsystems were designed, but it emerged from the shadow to continue functioning as before and was ready to transmit data for a second year. As a result, the launch of a similar spacecraft—Interplanetary Monitoring Probe-G, IMP G—being readied to replace it could be postponed until March 1969.

Explorer XXXV, launched in July 1967, provided data on the behavior of the solar wind in the vicinity of the moon and confirmed that the moon has a very small magnetic field, if any.

Scientists have concluded after analyzing data from Orbiting Solar Observatory III (OSO-III launched March 1967) that the center of this galaxy is a source of 50 million electron volt gamma rays. This gamma ray intensity is much greater than expected. Information supplied by all of the Orbiting Solar Observatories to date, including data transmitted by OSO-IV orbited in October 1967, has substantially increased scientific knowledge of the sun, because these spacecraft carry experiments able to observe and measure solar radiation that cannot penetrate the earth's atmosphere and be studied by earth-based observers.

Experiments aboard Applications Technology Satellite I (ATS-I), launched in December 1966 into a 22,300-mile geostationary orbit over the Equator, measured trapped electron fluxes and magnetic fields before and during a magnetic storm on January 13-14, 1967. The measurements showed that the spacecraft had crossed in and out of the region of trapped electrons and part of the time was outside the magnetosphere where it was exposed to energetic solar particles. This information will help in planning for the safe passage of astronauts traveling in a similar orbit through these regions. The finding is supported by OGO-III experiments.

**Sounding Rockets and Balloon Flights**

To continue its studies of the lower ionosphere, airglow, cosmic dust, stellar ultraviolet and X-radiations, auroras, and solar physics, NASA launched 71 scientific sounding rockets. In addition, it sent aloft 26 balloons carrying instruments primarily for astronomical observations. Among the significant sounding rocket launches were—

- Test flights of the boosted Arcas II and the single-stage Tomahawk vehicles, which were then added to the stable of operational rockets.
- The second flight of the Rice University (Houston, Texas) "Twins" experiment including instruments being developed for the Owl satellite.
- A test flight of the Solar Pointing Aerobee Rocket Control System (SPARCS) with a pointing accuracy of 5 to 10 arc seconds.
- Test flights of Injun V experiments on a Javelin vehicle.
- Second flight of a solar physics experiment using the Solar Capture and Tracking (SCAT) pointing control system with an accuracy of 5 to 20 arc seconds.
- Operationally successful flight of the high altitude (850 to 1200 miles) Astrobee 1500 rocket.
- Flight of the bioscience "Gravity Preference" experiment.
- Five flights of X-ray astronomy experiments using the Stellar Tracking and Positioning (STRAP) pointing control system with an accuracy of 5 to 20 arc seconds.

**Airborne Aurora Expedition**

A six week-study of the Aurora Borealis (the Northern Lights) and the polar cap airglow was made from a NASA jet airplane during the first three months of 1968 in a series of flights from Canada's Fort Churchill Research Range. The flights, which extended from Greenland to Alaska at altitudes of 32,000 to 40,000 feet, carried out the most intensive studies of the Northern Lights ever made. Thirteen experiments were aboard the plane—spectrometers, photometers, cameras, radio receivers, and a magnetometer—and 14 universities and research organizations participated.

Flying beneath auroras at 550 miles an hour, the aircraft canceled out the speed of the earth's rotation by flying against it and holding a constant position on the night side of the earth opposite the sun at latitudes above 60° North. Some of the flights afforded continuous views of auroras for more than five hours, and frequent trips were made to the north Magnetic Pole north of Greenland. In the course of the study, 40,000 auroral photographs were taken, and 180,000 feet of

magnetic tape recorded instrument readings from above five-sixths of the atmosphere of the world.

During many of the flights, experiments carried by the plane were coordinated with auroral and polar cap phenomena experiments of OGO-IV. Three times the aircraft crossed a spot in the northern magnetic field at the same time that the spacecraft crossed a complementary spot in the southern magnetic field. On six passes of OGO-IV over the northern hemisphere, the plane measured a group of auroras from below 40,000 feet while OGO-IV measured the same group from above that height. Also, some of the flights were coordinated with launches of scientific sounding rockets from the Fort Churchill Research Range.

This airborne aurora expedition proved for scientists the value of the high altitude observatory jet aircraft and showed that it could "stop time" for observations near both poles.

### Lunar and Planetary Programs

#### **Surveyor**

Surveyor VII, the last in the series of lunar soft landers, was launched on January 7 and two days later landed on the moon, about 18 miles north of the rim of the crater Tycho. (Fig. 2-3.) Earlier Surveyors were sent to lunar mare regions to scout potential landing sites for Project Apollo astronauts in the moon's equatorial belt, but this Surveyor was directed to an area of entirely different geological characteristics—the rugged, rock-strewn, ejecta blanket just north of this large ray crater. This hazardous region was chosen because it is well within the lunar highlands far removed from the mare basins previously investigated and is believed to be covered with debris excavated from deep beneath the surface of the highlands when Tycho was formed.

During the first lunar day (14 earth days) the spacecraft transmitted 21,038 TV pictures. (Fig. 2-4.) It survived the extreme cold of the two-week lunar night and sent back 45 more pictures in the course of the second lunar day. The alpha-scattering (chemical analysis) instrument, after completing a background count in the intermediate position, failed to touch down on the lunar surface. Through a series of intricate maneuvers, the surface sampler was used to force the alpha-scattering instrument all the way down. The surface-sampler was then used to pick up the alpha-scattering instrument after its first chemical analysis was completed and move it to two other locations for further analyses. These delicate operations demonstrated the versatility of the surface-sampler as a remote manipulation device and the precision with which its operations could be controlled from the earth.

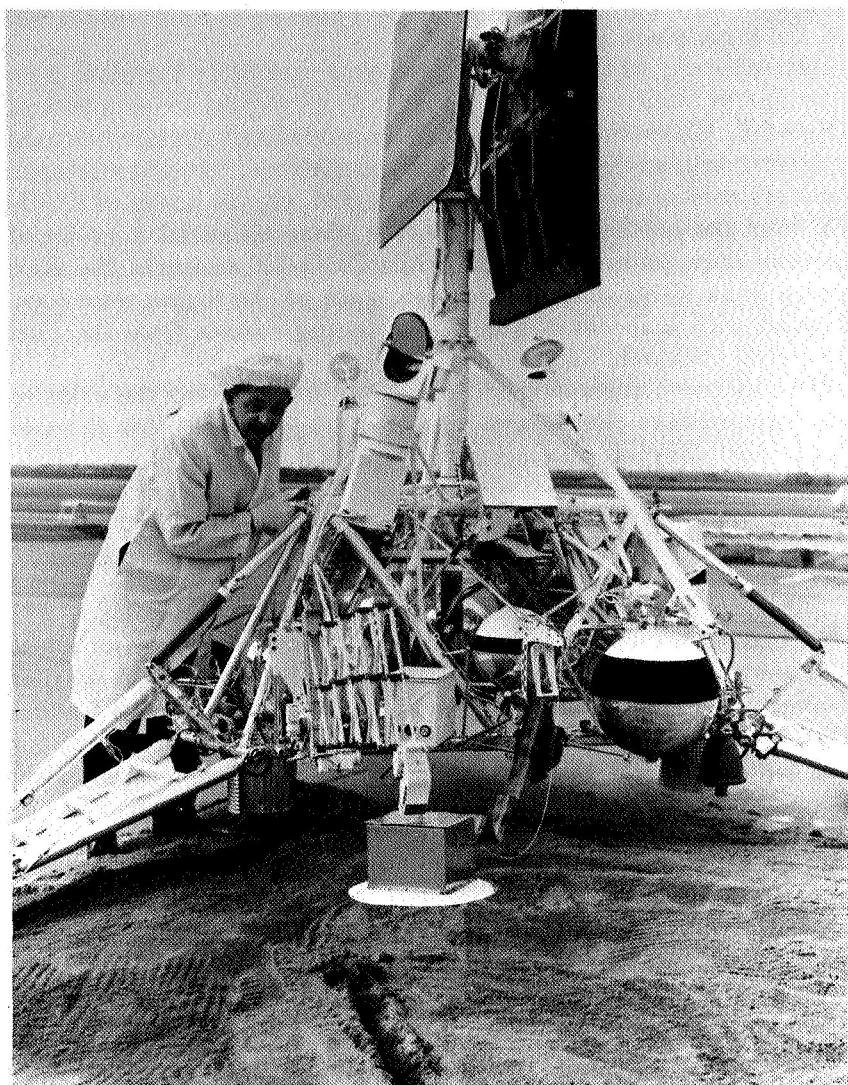


Figure 2-3. Test model of Surveyor VII.

From samples of the undisturbed lunar surface, a lunar rock, and an area dug up by the surface-sampler (fig. 2-5), about 66 hours of chemical composition data were obtained during the first lunar day. Thirty-four more hours of data were provided by the surface-sampler the second lunar day. This device dug numerous trenches, conducted static and dynamic bearing strength tests, picked up rocks, fractured and weighed a rock, and performed various other manipulations of

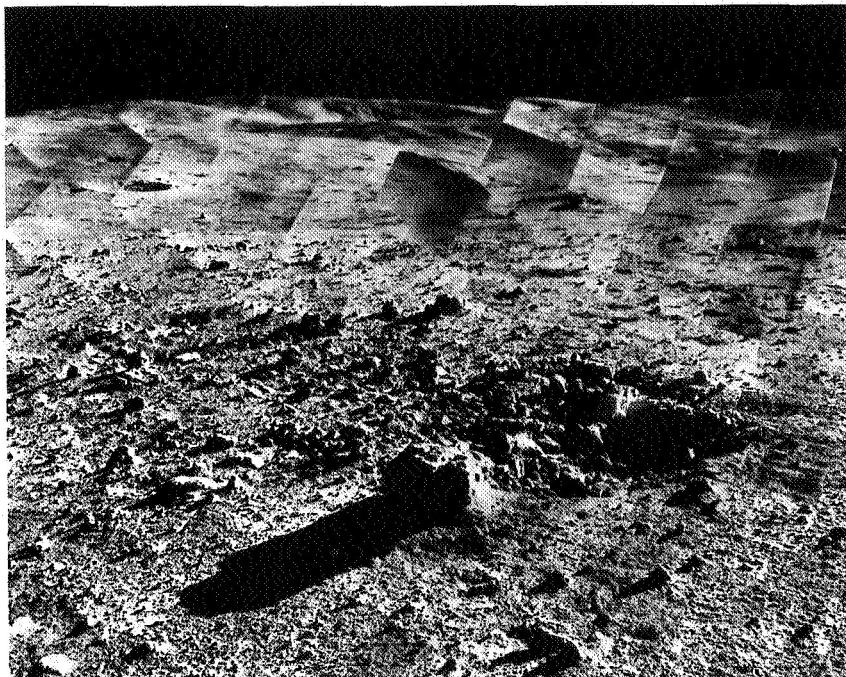


Figure 2-4. Spherical mosaic of Surveyor VII pictures of the moon.

the lunar material. In addition, Surveyor VII photographed the earth and carried out star surveys. Tiny laser beams from the earth were detected by the spacecraft's television camera in a special test of laser-pointing techniques.

Post-sunset operations were conducted for 15 hours after local sunset at the end of the first lunar day on January 25. At this time additional pictures of the earth and stars were obtained, as were observations of the solar corona. The spacecraft was turned off on January 26, about 80 hours after sunset. Second lunar day operations began on February 12 and continued until February 21.

#### Mariner

Mariner V, which passed by Venus at a height of about 2,540 miles last October (*18th Semianual Report*, p. 51), continued to orbit the sun. Telecommunications with the spacecraft were discontinued on December 1, 1967, and were scheduled to be resumed in July, 1968, at which time NASA plans to use its instruments to map ultraviolet and X-ray sources. Mariner will be positioned so that the instruments on board can scan the sun as the spacecraft continues in a heliocentric arc of approximately  $330^{\circ}$  for six months.

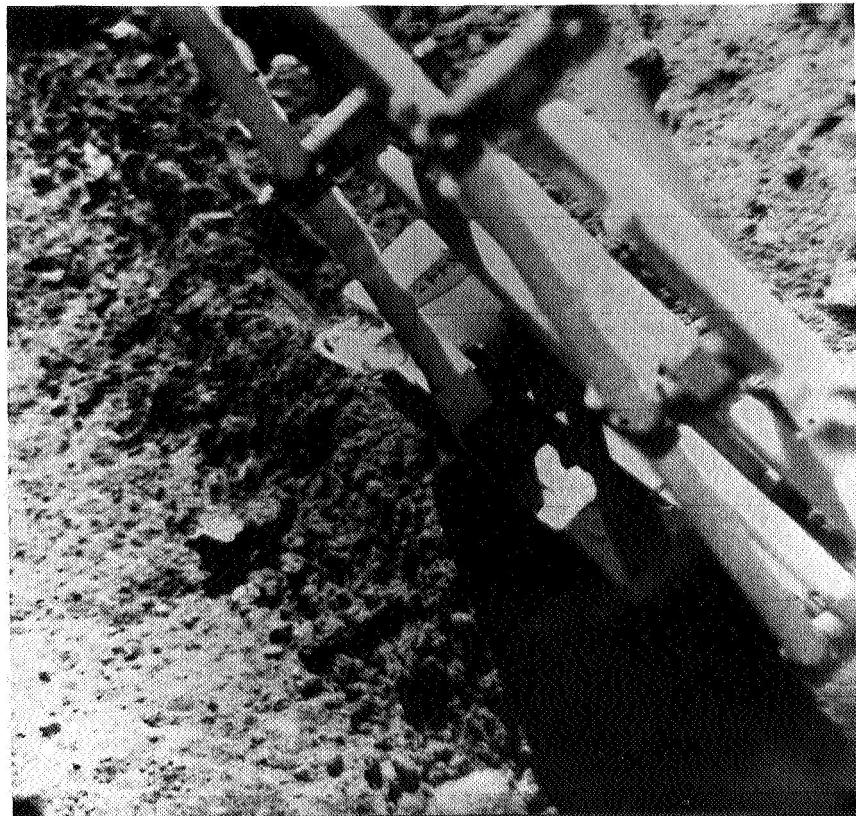


Figure 2-5. 12-inch trench dug by Surveyor VII.

*Mariner Mars 69.*—The Mariner Mars 1969 Program was initiated in December 1965 and the project assigned to the Jet Propulsion Laboratory (JPL), Pasadena, Calif. Two identical Mariner spacecraft will be launched on Mars flyby trajectories during the 1969 opportunity, each carrying two television cameras, an infrared radiometer, and an ultraviolet and an infrared spectrometer. Also on board will be a radio frequency occultation experiment and a celestial mechanics experiment.

This project progressed from the design and qualification stage to flight spacecraft assembly and testing. Subsystems of the Proof Test Model (PTM) passed their type approval qualification tests and were assembled into an integrated spacecraft. The assembled spacecraft, when subjected to further tests involving stresses greater than those to be expected in actual flight, assured engineers of the soundness of the flight spacecraft design. Flight hardware began to arrive at JPL in April and May, and by the end of June the first flight spacecraft

was completely assembled and ready for system testing. Subsystem hardware for the second flight spacecraft started to arrive in May, with final assembly scheduled for late June.

Significant progress was also made in mission design and operations. Experimenters agreed on the most desirable encounter conditions for a maximum return of scientific data. Planetary arrival dates of July 31 and August 5, 1969 were selected. These dates would provide photographic, as well as ultraviolet and infrared spectral coverage of the planet over the equatorial regions and extending to the south polar cap. Studies indicate that additional photographs of the planet may be taken as the spacecraft approaches from the sunlit side, its cameras being turned on as early as 78 hours before encounter which could provide up to 83 far-encounter pictures before the close-up or near-encounter sequence begins.

#### **Apollo Surface Experiments Program**

Qualification tests of Array A, one of the various combinations of the 10 experiments of the Apollo Lunar Surface Experiments Package (ALSEP), were completed in June. ALSEP is a geophysical station which will be left on the moon by astronauts to transmit lunar data back to earth for at least a year. The instruments making up this package are: a Passive Seismometer to provide data on the structure and processes of the moon's interior; a Lunar Surface Magnetometer to measure the magnetic field induced by the solar wind and detect any lunar magnetism; a Solar Wind Spectrometer to supply data on the energy of the solar wind at the moon; and combined Suprathermal Ion Detector and Cold Cathode Ionization Gauge experiments to measure the lunar ionosphere and atmosphere. (Figs. 2-6 through 2-10.)

The scientific objective with the highest priority in the Apollo Surface Experiments Program is to collect samples of the lunar soil and return them to earth for study. Astronauts are being trained in geology so that they will be able to gather these samples and also examine the lunar topography. The lunar samples collected will be distributed by the Lunar Receiving Laboratory to over 130 investigators throughout the world for analysis.

#### **Lunar Receiving Laboratory**

The Lunar Receiving Laboratory (LRL) at the Manned Spacecraft Center was built as a quarantine facility for astronauts and the lunar samples which they return to earth. The Laboratory's scientific instruments will determine the elemental, as well as the radioactive content of lunar samples and their inorganic and organic gases. LRL will also serve as a curator for the lunar samples, photographs, and other data returned by the astronauts.

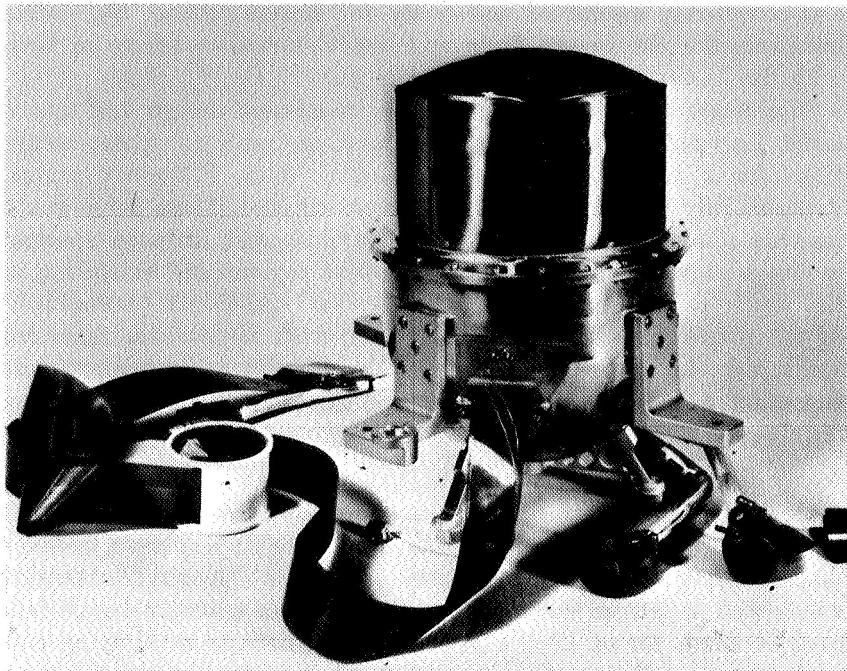


Figure 2-6. Passive Seismic Experiment.

During the past six months scientific equipment was being installed at the facility and techniques for operating the Laboratory were being planned. Teams of bioscientists and physical scientists were assisting NASA in developing methods to assure the maximum return of data from the lunar samples obtained. Similar teams of experts will be selected to conduct scientific studies within the LRL during the quarantine period.

#### Topographic and Geologic Mapping

Geologic maps of Apollo prime sites (scale 1:100,000 and 1:25,000) were completed for use in selecting final manned landing sites and carrying out operations on the moon's surface. The U.S. Geological Survey will incorporate these maps into flight packages. More detailed geologic maps at a 1:5,000 scale are planned for the final Apollo sites.

Also, geodetic and cartographic studies were developing substantial data on the size, shape, and topography of the moon in its equatorial areas where astronauts will land on sites partly determined by Lunar Orbiter photography and tracking data. Stereoscopic and photo measurements were used to project surface slopes and relative heights between surface features. The development and correlation of such

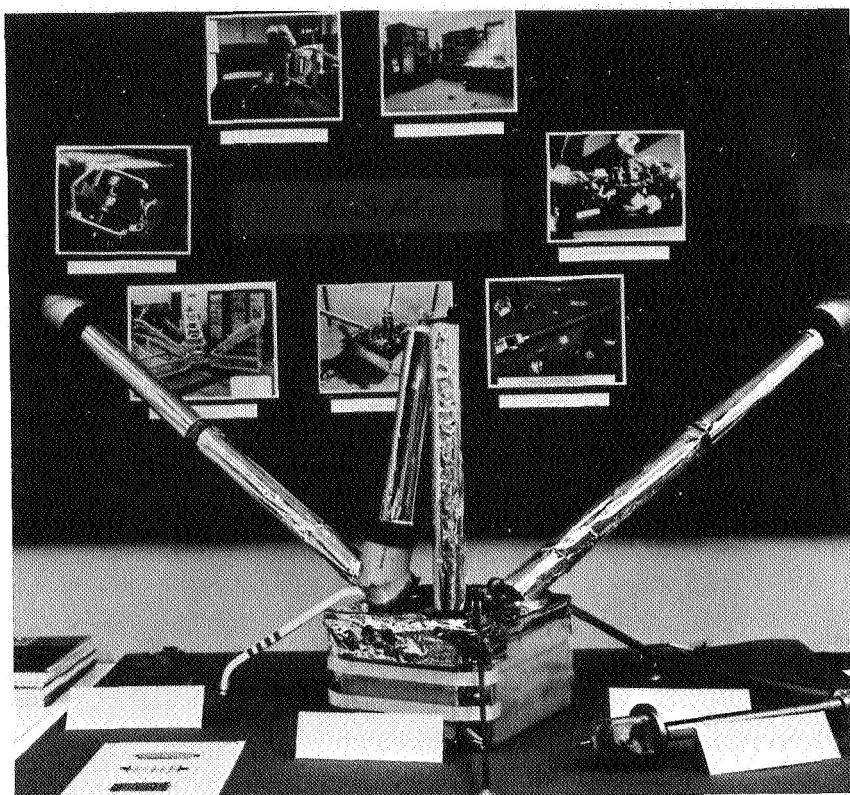


Figure 2-7. Lunar Surface Magnetometer.

topographic information for eight areas photographed by Lunar Orbiter permitted NASA to select and evaluate the operational requirements for five candidate Apollo landing sites. Studies of the Orbiter data were also affording scientific investigators a better understanding of the shape and internal structure of the moon.

A Mars planning chart was published for the Mariner flyby of the planet in 1969. The multi-colored chart is in three sheets and illustrates the expected appearance of Mars at that time.

### Advanced Programs and Technology

#### Advanced Studies

A study was completed to determine if electric propulsion and solar array power could be combined for a 1975 flyby of Jupiter. Based on present technology solar electric propulsion using multi-kilowatt, fold-out solar arrays was found to be practical and feasible for unmanned planetary missions by the mid-1970s, and, in addition, to

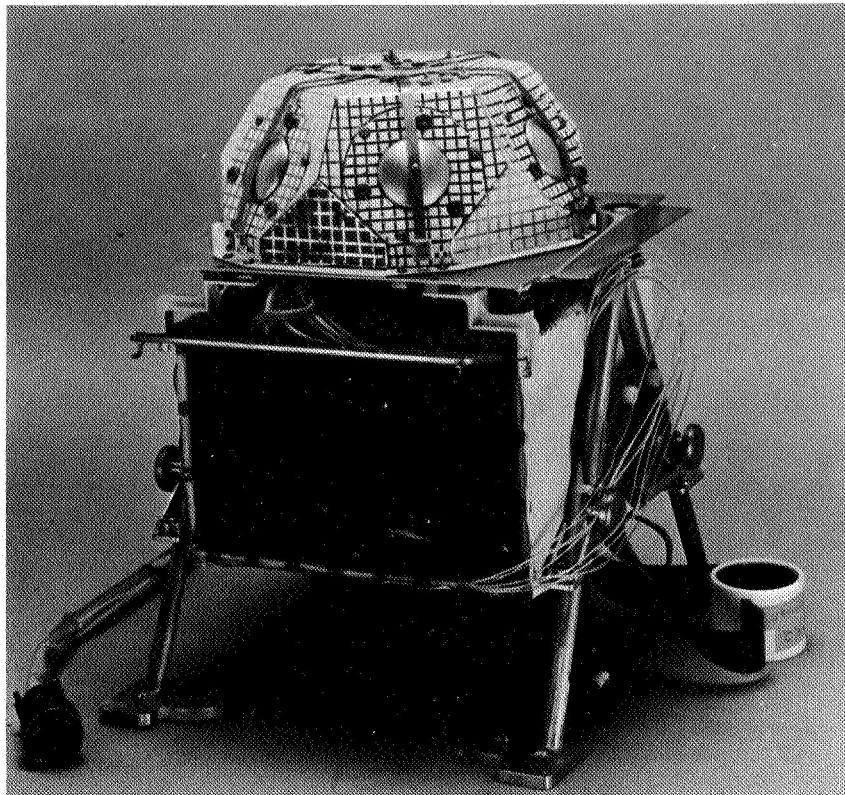


Figure 2-8. Solar Wind Spectrometer.

possess some inherent advantages over typical chemical rocket-boosted ballistic missions. Increased payload capability, greater mission flexibility, and larger amounts of available power at destination were among these potential advantages.

A study was also completed of a Venus flyby-entry probe mission using an Atlas-Centaur launch vehicle. The probe would make detailed measurements in the Venus atmosphere, but would not survive on the Venusian surface.

To help plan future missions, a preliminary investigation was made of the problems of utilizing unmanned spacecraft to return surface samples of Mars to earth. This study assumed the use of a single Saturn V launch vehicle to return a one-pound sample.

#### **Advanced Planetary Missions Technology**

Spacecraft conceptual designs, trajectories, orbits, weight tradeoffs, subsystem requirements, and launch vehicle capability for a Mariner spacecraft to orbit Mars were studied and specific requirements for

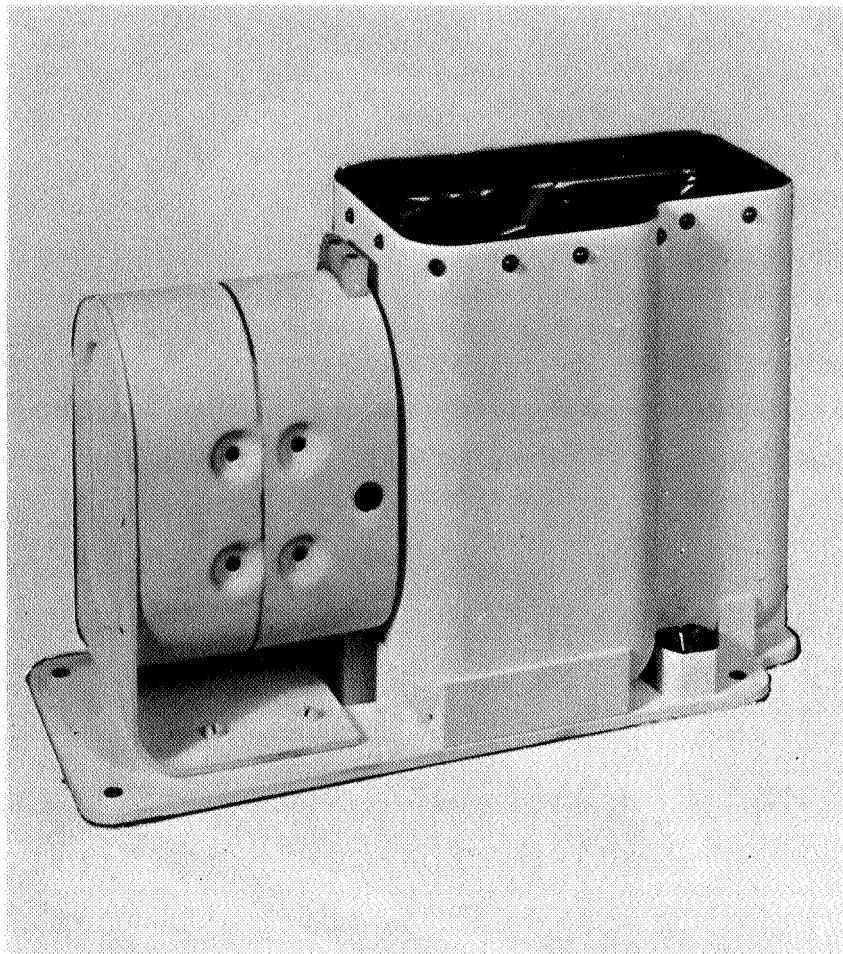


Figure 2-9. Cold Cathode Ionization Gauge.

this mission defined. Also, conceptual designs for all subsystems were completed. Similar design studies were made of a Titan class launch vehicle to orbit a Mariner spacecraft and land a survivable payload on Mars. Studied were a soft lander, a hard lander, alternative modes of planetary capsule entry, and the use of spacecraft propulsion for interplanetary injection and orbit insertion.

Synopses were prepared for alternative missions to Mars and for missions to Venus and Mercury in the early 1970s. In addition, advanced development of an orbit-insertion propulsion engine for Mariner class missions to Mars was started. The engine's systems and components were analyzed, some of its hardware procured, and tests begun.

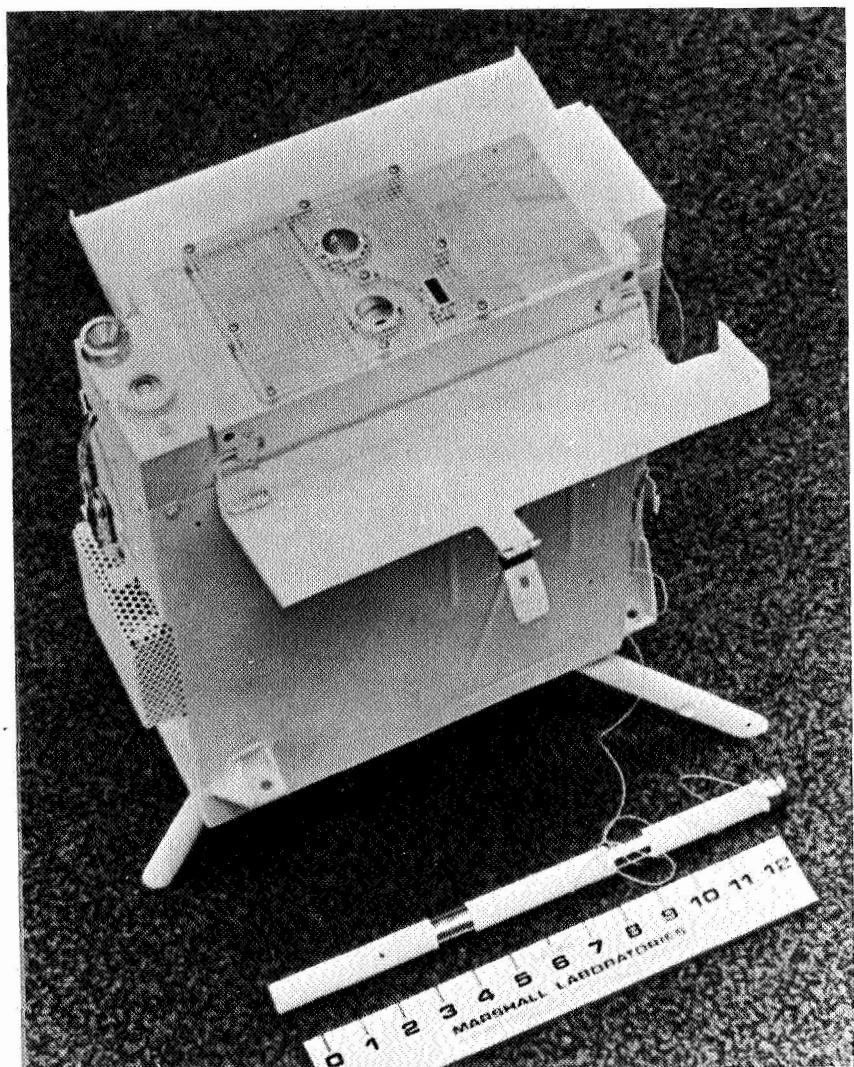


Figure 2-10. Suprathermal Ion Detector.

Equipment was procured to simulate the extremely high heating rates and pressure load that Venus entry probes will encounter. Entry heating is a critical problem for these probes, and this equipment will be used to develop suitable new heat shields.

#### **Advanced Technical Development and Sterilization Program**

A small, typical liquid propulsion system was fired after several heat sterilization cycles, indicating the feasibility of developing a propulsion system for soft landings on Mars and Venus. New sensory

devices including solid-state radiation detectors, photomultiplier tubes, a vidicon tube, a radio transmitter, and an antenna were added to the growing list of qualified sterilizable spacecraft items.

A special chamber to test the sterile assembly and repair of a planetary entry-lander passed its design phase and construction was begun. This chamber concept promises to increase the reliability of a planetary lander by allowing last-minute repairs to be made to the spacecraft's hardware without repeating its sterilization cycle. In addition, a demonstration model of a typical Mars hard lander package was assembled of hardware in the advanced development stage, heat sterilized, and then drop-tested successfully.

New techniques investigated to increase the yield and reduce the time and cost for screening piece parts of planetary spacecraft included a resistor screening technique which promises to cost only one tenth as much as conventional screening methods.

## Bioscience Programs

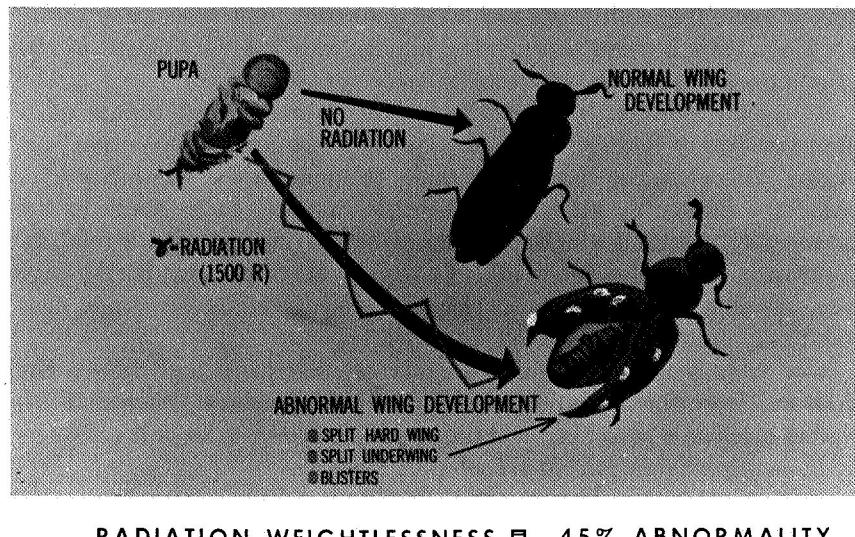
### Biosatellites

The scientific results of the Biosatellite II flight in September 1967 were presented at a February symposium held at the National Academy of Sciences. This satellite—carrying 13 experiments to study the biological effects of weightlessness and of weightlessness combined with an onboard radiation source—was recovered after 45 hours in an orbit between 187 and 202 miles. (*18th Semianual Report*, p. 54.)

Experimenters found an interaction between radiation and weightlessness during space flight. This interaction varied for different test organisms from increasing the effects of radiation four times to decreasing its effect slightly, but significantly. Earlier control studies of several of the experiments indicated that weightlessness but not vibration interacted with radiation. (Fig. 2-11.)

Experiments aboard the Biosatellite on the biological effects of weightlessness seemed to validate use of the horizontal clinostat for simulating weightlessness. The clinostat, used by botanists for over a century, rotates a plant horizontally fast enough to keep it from responding to gravity in any one direction. (*18th Semianual Report*, p. 58.) The results of the Biosatellite experiments were similar enough to those of the clinostat to assure bioscientists that the clinostat may nullify or compensate for gravity's effects on plants having a slow gravitational response time.

The prototype and flight spacecraft for the 30-day Biosatellite D mission with a pigtailed monkey were fabricated and assembled. Subsystems of the prototype model were undergoing functional testing following initial checkout of all systems with the primate. (Fig. 2-13.)



RADIATION-WEIGHTLESSNESS = 45% ABNORMALITY

WEIGHTLESSNESS ONLY = 30% ABNORMALITY

GROUND (RADIATION) CONTROL = 30% ABNORMALITY

Figure 2-11. Effects of radiation and weightlessness on the flour beetle (*Tribolium*)

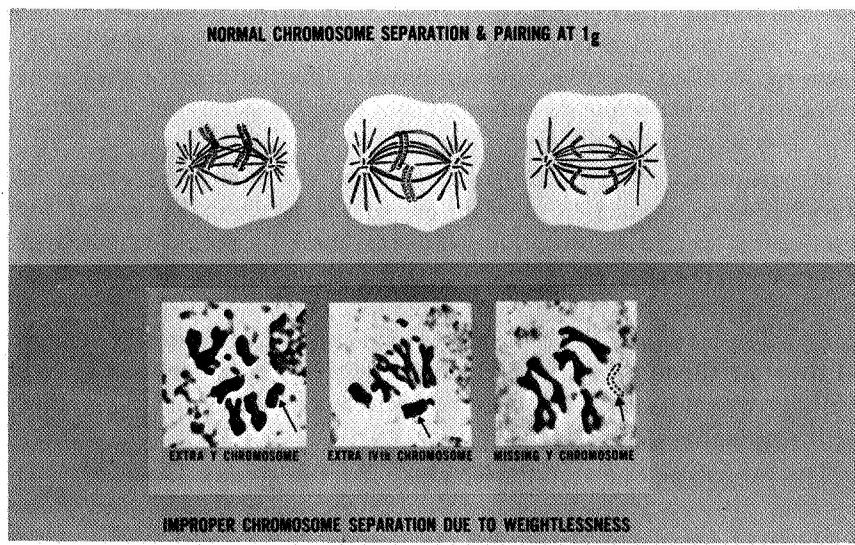


Figure 2-12. Weightlessness and cell division.



Figure 2-13. Primate in couch and restraint during Biosatellite test.

This Biosatellite is scheduled to be flown during the second quarter of 1969.

#### Exobiology

Based on data supplied by expeditions in the dry valleys of the Antarctic, exobiologists hope to formulate a theory of "Martin ecology" to help in designing instruments for detecting life on Mars. The field investigations indicated that life forms may exist anywhere that liquid water is at least occasionally present. Mostly aerobic organisms (those growing only when molecular oxygen is present) were found in these valleys. Accordingly, bioscientists theorize that if there is liquid water on Mars life could exist.

By using heat, a new technique was developed to enable a gas chromatograph to detect as few as 100,000 bacteria. The gas chromato-

graph using this method would not be quite as sensitive as some others, but its instruments could be extremely simple and it might well become one of the first experiments in investigations of Mars.

Particles containing amino acids similar in structure to the *proteinoid microspheres* synthesized in the laboratory—although probably not fossils of living organisms—were found in 3 billion-year-old rocks from Southwest Africa. Investigators believe that nature could have performed such experiments quite early in the earth's history, and, if so, the laboratory experiments could provide a key in understanding the origin of life.

#### **Planetary Quarantine**

The problem of preventing the transfer of living organisms, or life-related molecules between the moon and planets remained substantial, but was beginning to yield to research and management. A major step toward solving this complex problem was the completion of the Lunar Receiving Laboratory (LRL) at Houston, where final provisions were being made for quarantining astronauts returning from the moon with lunar samples (p. 47). Each recovery ship will carry a mobile isolation unit on its deck into which the crew and samples will enter through a flexible tunnel attached to the capsule of their spacecraft. The mobile unit will then be flown to Houston where the astronauts and the samples will be unloaded into the biological barrier. Clinical studies of the crew and microbiological examination of the samples during the quarantine period will show whether hazardous biological or chemical agents are present.

The Public Health Service will operate a laboratory for NASA at the Kennedy Spacecraft Center to determine the microbiological contamination of the Apollo spacecraft when they are launched, so that if any new life forms are identified when the spacecraft return from the moon they can be classified as not being from the earth. Determining the number of organisms on planetary landing spacecraft is of primary importance in deciding the extent of the sterilization needed to counteract this contamination.

Research on methods of sterilizing spacecraft continued to promise less drastic, more economical sterilization procedures. Analyses indicated that the probability of release of organisms remaining on the spacecraft was not as great as expected earlier, which could result in shorter periods of heat application and less chance of damage to the spacecraft.

#### **Environmental Biology**

At the University of Iowa, rats centrifuged daily for almost 24 hours at 3.0 and 1.7 g consumed less water during the first day of the experi-

ment, but their water intake slowly returned to normal. (The cumulative net difference between water intake and urine output was lower in the experimental than the control animals.) The rats were dehydrated throughout the first two days of centrifugation and the volume of their plasma was reduced. Within a week the centrifugation decreased the number of their red blood cells. Loss of tissue fluid seemed to be the primary source of an increase in urine. Also, studies at the University of California, Davis, indicated a relationship between the number of lymphocytes—white blood cells—and survival of the test animals after acceleration. A marked decrease in their white blood cells within a few weeks after exposure to a 3 g chronic acceleration generally forecast their death. (*18th Semiannual Report*, p. 58.)

Research at the University of Kentucky on immobilized animals revealed the influence of Vitamin C (ascorbic acid) on the amount of calcium. Without this vitamin the calcium loss of the animals increased by 37 percent and replacement of lost calcium decreased by 27 percent. Vitamin C supplements improved the replacement of the calcium lost.

#### **Behavioral Biology**

To find out if extended gravity level preference studies could be carried out in space, NASA and scientists of the University of Kentucky designed and launched two Aerobee rockets to examine the responses of white rats to artificial gravity (*18th Semiannual Report*, p. 59). Preliminary analyses of data from the two rocket flights indicated that the rats preferred gravity between 0.5 and 1.3 g and quickly avoided higher and lower levels of gravity. More conclusive data are expected from the two other rocket flights planned in these studies. Related ground-based tests at the University permitted a monkey in the cab of a large centrifuge to control the g level by pressing a lever which changed the rotation rate. These, and similar laboratory tests with trained rats, showed that the animals prefer earth's gravity when exposed to levels of 1 g and above.

Experiments at Johns Hopkins University have established that animals sense and respond to environmental changes. Investigators there built a gas-control system to study the effects of changes in gases on animal behavior. The system changes oxygen and carbon dioxide concentrations in a chamber containing animals able to press levers transmitting brief electrical impulses to their brains to produce pleasurable sensations. Results of these experiments showed that changes in oxygen concentration impair the performance of the animals, and that the extent of the impairment can be reliably predicted from the amount of oxygen in their environment.

Scientists at Emory University (Atlanta, Ga.) and the University of California (Los Angeles) are developing a method using electricity to locate brain structures. The technique, which measures voltage generated between a moving and a fixed electrode, is being used for more accurate insertions of electrical devices in monkeys used as subjects in space related experiments. Early results with human brains removed at autopsy indicate that the technique can be applied to the human brain.

#### **Physical Biology**

A remote telemetry technique through closed circuit TV was developed to follow temperature changes in rats. Investigators observed that no particular type of activity caused consistent temperature changes, but that each behavioral activity produced a response in body temperature. Also, large free roaming mammals were tracked by remote telemetry from a distance of 17 miles, and their behavioral and temperature activity recorded for about four days.

A telemetric thermal probe for use in mammals was developed by the Franklin Institute in Philadelphia. This probe monitors circulatory phenomena, and oscillations in temperatures between 18° and 40° C. which could indicate changes in cellular composition or activity.

Data storage and retrieval using the electron microscope were demonstrated at the University of Chicago. A new grainless film used with this microscope reduces written and printed matter 50,000 times, compressing hundreds of pages of a book to fit on an ordinary microscope slide, which is projected onto a screen for reading.

#### **Light and Medium Launch Vehicles**

NASA used Scout, Delta, Agena, and Atlas-Centaur launch vehicles for its unmanned space missions during the period.

##### **Scout**

Scout vehicles launched the solar radiation Explorer XXXVII on March 5, the Reentry F turbulent heating experiment on April 27, the ESRO II international cooperative satellite on May 16, and orbited a Defense Department satellite on March 1.

##### **Delta**

Delta began 1968 by establishing a new NASA record of 23 successful consecutive launches when it orbited Explorer XXXVI (GEOS-II) in January. Also, the Surveyor retromotor (TE-364) was adapted as a third stage for the Delta vehicle, and its first launch was scheduled for early July. In addition, the long tank Thor (Thorad) was incorporated as a booster for the Delta launch vehicle, and its first use was

scheduled for the July launching of the Radio Astronomy Explorer (RAE) satellite.

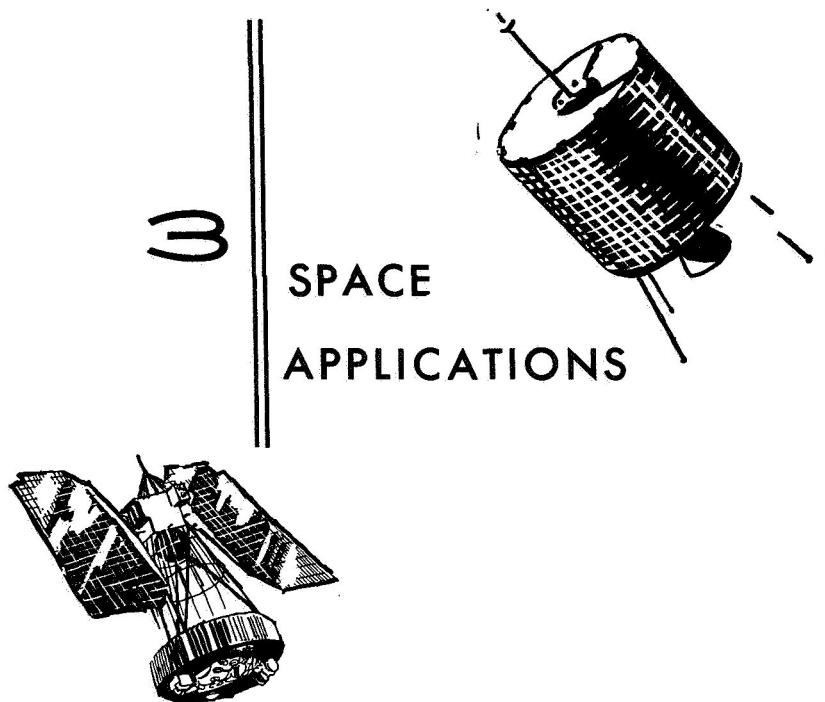
#### Agena

Atlas-Agena successfully orbited OGO-V on March 4, marking the first NASA launch using this vehicle (p. 37). The Thorad-Agena D launch vehicle carrying Nimbus B and an Army SECOR satellite was destroyed by the range safety officer two minutes after launch on May 18. He acted because a failure in the flight control system of the Thorad caused it to cross the left range safety boundary.

*Launch Vehicle Status.*—Phase-out of the Atlas-Agena was completed after the OGO-V launch with the transfer of the launch facilities to the Air Force in March. Thorad-Agena will continue in the NASA stable of vehicles and will be used to launch Nimbus and the Orbiting Geophysical Observatories.

#### Atlas-Centaur

The final spacecraft in the Surveyor series (Surveyor VII) was successfully launched on an Atlas-Centaur vehicle in January, completing initial operational phase of the Atlas-Centaur program with seven successes in as many attempts. Two flights using Atlas-Centaur are scheduled for the last six months of 1968—an Applications Technology Satellite (ATS-D) and an Orbiting Astronomical Observatory (OAO-A2). They will be the first use of the Atlas-Centaur for earth-orbital missions.



NASA was developing the next generation of operational weather satellites for the Environmental Science Services Administration, planning to continue providing launch services for the Communications Satellite Corporation, and demonstrating that the Applications Technology Satellites could provide meteorological coverage of the mid-Atlantic and Pacific Oceans and the middle part of the U.S.; pinpoint vehicle locations on land, sea, and in the air; and communicate with ships at sea. In addition, a NASA geodetic satellite transmitted data to hundreds of tracking stations around the world.

### **Meteorological Satellites**

#### **ESSA and TIROS**

On May 27 the one-millionth cloud cover picture from the combined TIROS and ESSA (TOS) satellites was received from the ESSA VI spacecraft. (Fig. 3-1.) These photographs include all taken by the ten TIROS research and development satellites and the six ESSA satellites which NASA turned over to the Environmental Science Services Administration. The other ESSA satellites, II, III, and V, also continued to provide global meteorological satellite data on an operational basis. Spacecraft yet to be launched in the ESSA series—TOS-E, -F, -G, and -H—were ready to be orbited as needed to maintain the national operational meteorological system.

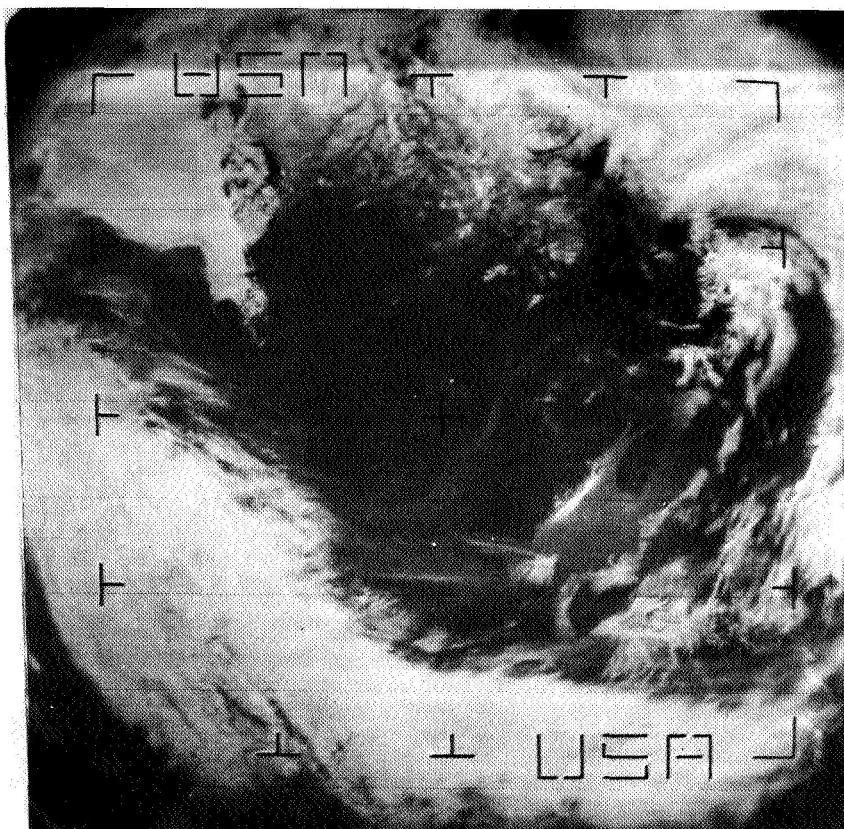


Figure 3-1. The 1,000,000th TIROS-ESSA cloud cover picture.

The next generation of operational weather satellites (the TIROS-M class) were being developed by NASA for ESSA. The mechanical and thermal test models, and the antenna test model of this new TIROS were tested successfully. (Fig. 3-2.) Also, assembly of the electrical test model began, and some components of the flight spacecraft were delivered.

#### Meteorological Experiments on ATS

The spin scan camera aboard the first Applications Technology Satellite (ATS-I), launched in December 1966, was providing excellent meteorological coverage of the Pacific. (Fig. 3-3.) Evaluation of its Weather Data Relay (WEFAX) experiment indicated that such a system is extremely useful. The ATS-III spin scan color camera (p. 67), image dissector camera, and Omega Position Location Experiment, OPLE, were supplying similar meteorological coverage of the mid-Atlantic and the middle section of the United States.

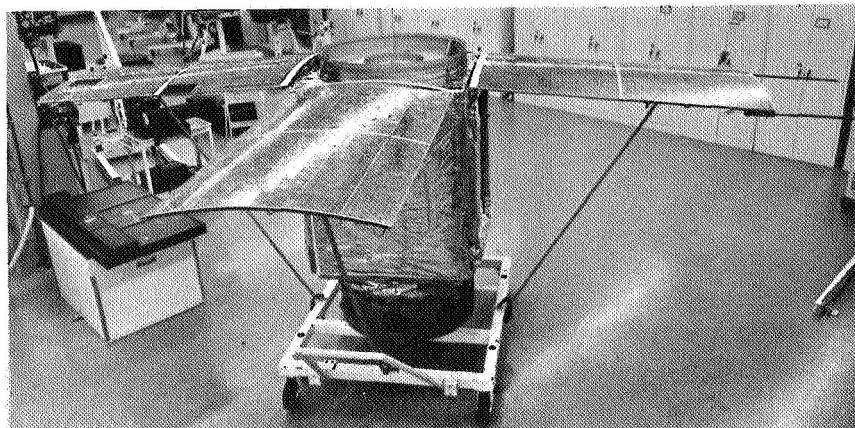


Figure 3-2. TIROS-M mechanical and thermal test model.

### Nimbus

The Nimbus II spacecraft successfully completed two years in orbit on May 15. Although its Automatic Picture Transmission system and yaw rate gyro ceased operating after 23 months, sun sensors on the solar paddles and a yaw rate gyro back-up system provided yaw data

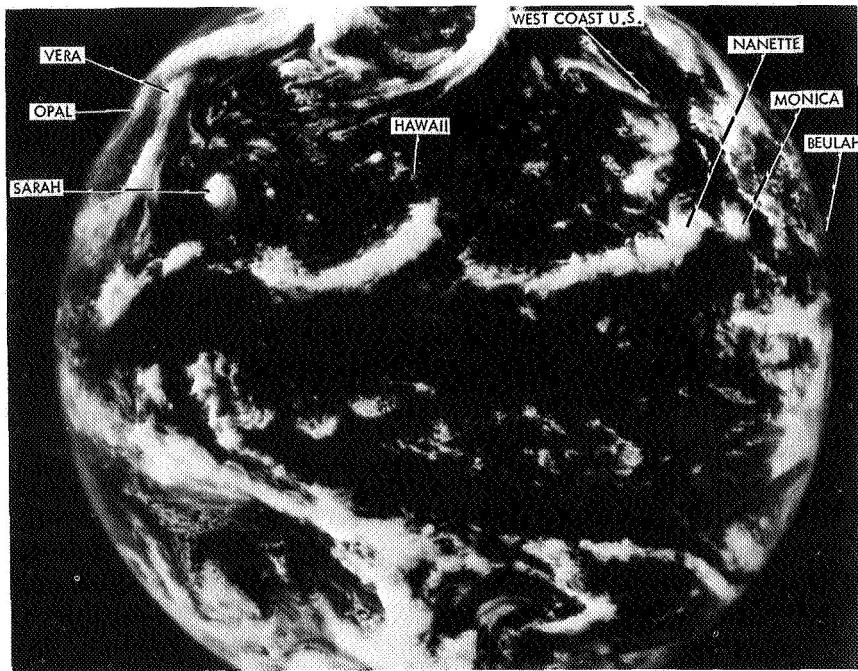


Figure 3-3. ATS-I photographed six cyclones in September 1967.

and prevented the loss of the spacecraft. The Advanced Vidicon Camera System was operating over North America in real time only due to the position of Nimbus II in relation to the command and data acquisition stations. (*18th Semiannual Report*, p. 65.)

The third Nimbus (Nimbus B) was launched on May 18 on a long tank, thrust-augmented Thor-Agena. Fourteen earlier launches by this vehicle were successful, but in this case, about 13 seconds after lift-off an unstable oscillation began to appear in the yaw channel of the Thor control system. The instability increased during the flight, and after about 2 minutes the range safety officer destroyed the vehicle. Preliminary analyses of flight telemetry data indicated that the most likely cause of the failure was a mechanical misalignment of the Thor yaw rate gyro.

Since there were enough Nimbus B experiments (fig. 3-4) and subsystem back-up hardware, a replacement for Nimbus B could be assembled quickly and tested. The repeat mission (Nimbus B2) was scheduled to be launched in April 1969.

Nimbus D was on schedule for a 1970 launch, its harness mock-up about 80 percent completed. The satellite's Cloud Altitude Radiometer experiment (fig. 3-5) was deleted from the payload.

Thirty-three proposals were received from industry for the Nimbus E mission, and a definition contract was signed in June. Reviews by

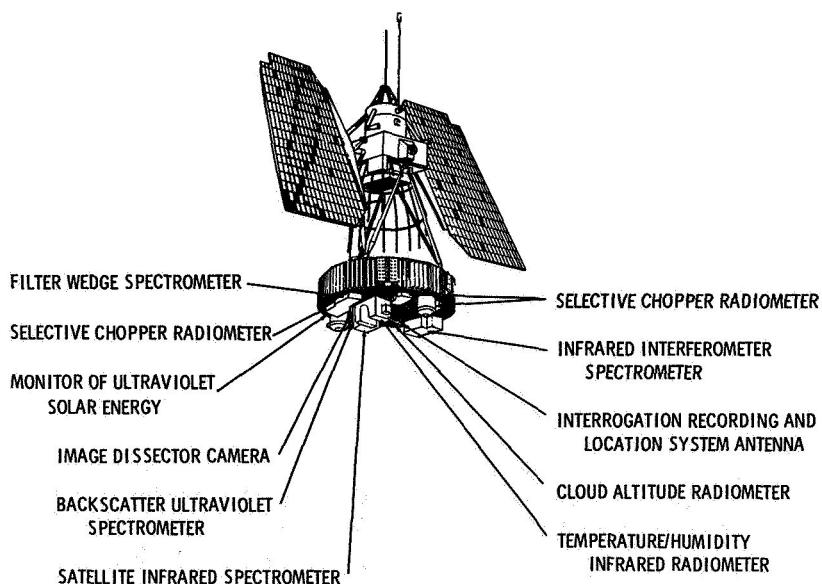


Figure 3-4. Nimbus B experiments.

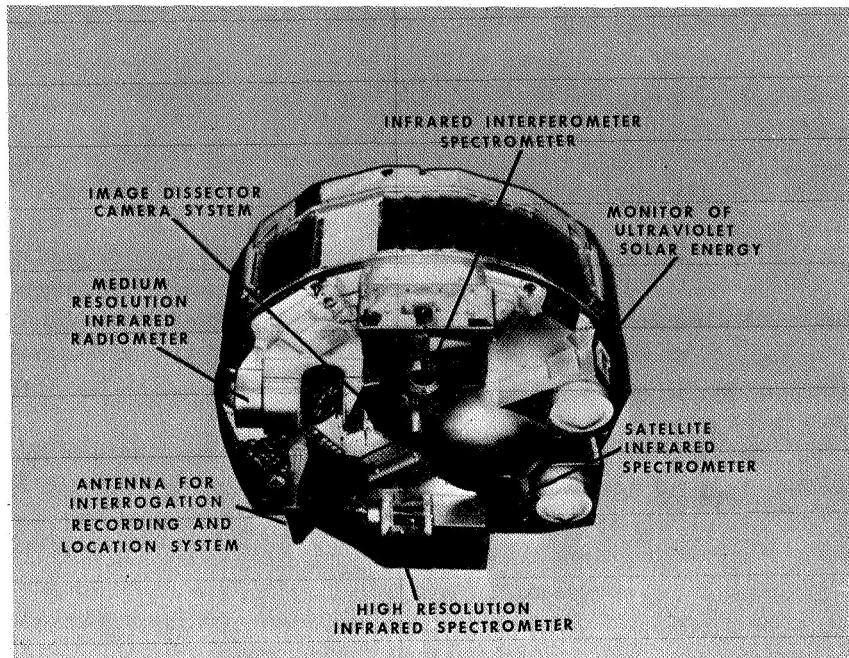


Figure 3-5. Nimbus D experiments.

appropriate committees were made, and a payload will be selected in a few weeks.

#### Meteorological Sounding Rockets

Sounding rockets obtained meteorological data and explored the atmosphere between 20 and 60 miles above the earth. Nike Apache rockets used acoustic grenades, pitot-static tubes, and light-reflecting or luminous-vapor experiments to determine wind, density, temperature, and pressure vertical profiles. In addition, special sensors for measuring ozone, water vapor, and ultraviolet radiation were flown in studies of energy sources in the upper atmosphere.

NASA and the U.S. Army continued to work together to develop an inexpensive meteorological sounding rocket system for obtaining data from the atmosphere at altitudes of 20 and 60 miles. Feasibility demonstrations of a self-consuming rocket case and fragmentable rocket nozzle were conducted. After performing reliably in ground tests during rocket motor burning, the rocket case broke up into particles which could not be a falling mass hazard in a free fall to earth. Descent devices to replace the conventional parachute were also under development. Such items would be able to function in air less than one hundredth of one percent the density of air at sea level.

## Communications Satellites

### INTELSAT I

The first commercial communications satellite, Early Bird or INTELSAT I, was launched by NASA for the Communications Satellite Corporation (ComSat) in April 1965; it continued to operate satisfactorily, although its design lifetime was 18 months. (Table 3-1, *18th Semiannual Report*, p. 68.)

### INTELSAT II

Three spacecraft in the INTELSAT II series—orbited by the Agency for ComSat in January, March, and September 1967—continued to supply commercial satellite service to over two-thirds of the world. Larger and more powerful than the first INTELSAT, each of these satellites provides 240 two-way voice circuits and is able to operate with several earth stations simultaneously. INTELSAT II, designed to operate for three years, can carry on telephone, telegraph, data, facsimile, and black and white or color TV transmissions. These satellites will also provide communications support for NASA's Apollo manned space flights.

### INTELSAT III

NASA served as a technical consultant to ComSat and the Federal Communications Commission (FCC). For ComSat, NASA participated in a review and assessment of the INTELSAT III program, conducting two technical reviews and reporting their findings to the Corporation and the FCC.

The first INTELSAT III, scheduled to be launched in September, has 1,200 two-way voice channels and is designed to operate for five years.

### INTELSAT IV

During 1967 ComSat continued its studies of more advanced spacecraft of the INTELSAT class to handle the requirements of the growing traffic in the commercial communications satellite network. In February 1968 the Corporation requested proposals for an advanced version of INTELSAT III; called for the launch of the first INTELSAT IV late in 1970; and hoped to complete evaluation of proposals and select a contractor within several months. The INTELSAT IV satellite would be larger and more sophisticated, providing at least 5,000 two-way voice circuits, and with a greater operational flexibility than earlier spacecraft in the INTELSAT series. Its operational lifetime would be seven years.

NASA would provide ComSat with launch support similar to that supplied for INTELSATs I, II, and III. However, the 2,452-pound

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INTELSAT IV—compared to the 641-pound INTELSAT III and the 357-pound INTELSAT II—would require a larger launch vehicle of the Atlas-Centaur or Titan Agena class. In response to requests from the FCC and ComSat, NASA provided technical advice on the stabilization system for INTELSAT IV.

### Navigation and Traffic Control Satellites

#### OPLE Tests

In the first of a series of tests to fix the position of a moving vehicle, the Omega Position Location Experiment (OPLE), aboard Applications Technology Satellite III (ATS-III) 22,800 miles above the earth, came within 1 to 2 miles of locating a station wagon. The vehicle used in the April test was equipped with a VLF antenna to receive Omega signals and a VHF antenna to communicate with ATS-III; it was moving at speeds up to 60 miles an hour.

Another test with this position location experiment, in May, was carried out with one of NASA's aircraft outfitted with a VHF antenna for ATS-III's signals and a VLF antenna for OPLE testing at higher speeds. The OPLE system operated satisfactorily at aircraft speeds as great as 185 miles an hour. Aircraft reception of the Omega signals was good, and transmission of these signals to the satellite was satisfactory. OPLE located the aircraft within about 5 miles of its "true" position.

#### Navigation Satellites

Responding to an expressed interest of the Federal Aviation Administration in "conducting, as soon as possible, an experimental program which will demonstrate the communications and position determination performance of an 'L' band system for aircraft or overseas flight," NASA began to determine if ATS-E (Applications Technology Satellite E); could carry an "L" band transponder. If this experiment is performed with ATS-E, the FAA would provide a suitably equipped aircraft.

In addition, the Maritime Administration conducted communications and range-navigation tests between the SS *Santa Lucia*, a commercial vessel sailing from New Jersey to Chile, and the ATS-I and III satellites. Preliminary analysis of the tests indicated that VHF communications between ocean-going ships and satellites can include voice transmissions, radio-teletype, data transmissions, time signals, and weather facsimile. No interference to or from the radar, HF radio, or VHF ship-to-shore aboard the *Santa Lucia* was reported. Additional tests of this type were planned for 1968 and 1969.

### **Applications Technology Satellites**

Experiments continued with Applications Technology Satellites (ATS) I and III, launched in December 1966 and November 1967, and their performance was excellent. From an altitude of 22,300 miles over the Pacific Ocean ATS-I was providing cloud cover data for 40 percent of the earth (p. 61).

The ATS-III spin scan color camera, whose red channel failed temporarily, recovered long enough to take a series of color pictures of the Western Hemisphere. Although its red channel failed again later, tornadoes in the U.S. were photographed extensively in blue and green light. The resulting data (from observations at 10- and 20-minute intervals) should help determine whether satellite observations can form the basis of an accurate tornado warning system. Also, the satellite carried out VHF communications experiments in locating aircraft and ships, and collected data from remote hydrological and seismological stations (p. 66).

The ATS-D spacecraft was assembled, completed its environmental tests, and was shipped to Cape Kennedy early in June for a planned launch in July (fig. 3-6).

### **Geodetic Satellites**

#### **PAGEOS**

The passive balloon satellite, PAGEOS-I, entered its third year of successful performance in orbit about the earth on June 23, and showed few adverse changes in its orbit and shape. Some of the satellite's prime optical observation systems were relocated, and considerable progress was made in the acquisition and reduction of observation data. The data will be forwarded to the Geodetic Satellite Data Service at the Goddard Space Flight Center.

#### **GEOS**

GEOS-I, launched in November 1965, became inoperative in December 1966. Two of its Doppler beacons provided some useful tracking data until they stopped operating in January of this year. Its gravity gradient stabilization system continued to function enabling the satellite to maintain its altitude and keep in a well-defined orbit. The corner cube reflectors of the spacecraft are oriented to permit it to be observed by laser tracking stations. The Goddard Space Flight Center has used GEOS-I to check out the performance of fixed and mobile laser tracking systems. Optical and electronic observation data obtained earlier by GEOS-I were being analyzed.

GEOS-II (Explorer XXXVI) was launched on January 11 into an orbit ranging between 670 and 977 miles. The geodetic satellite car-

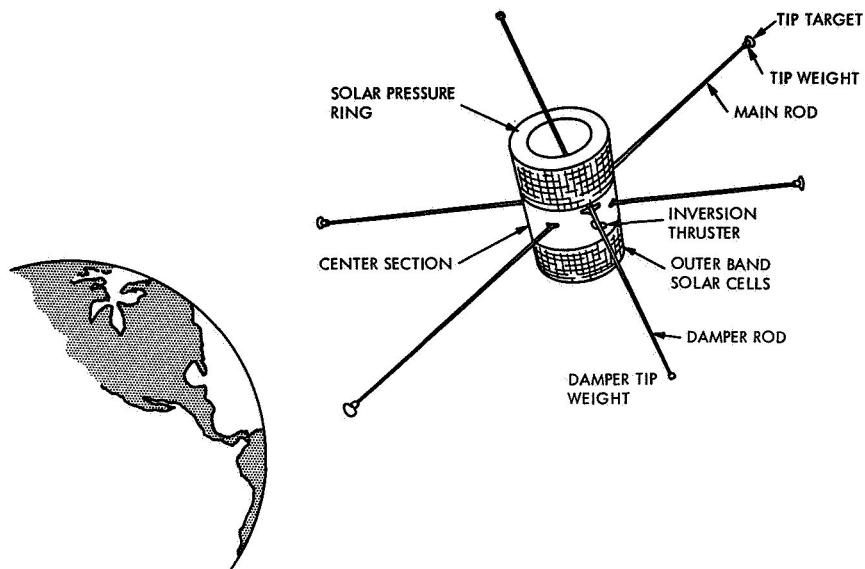
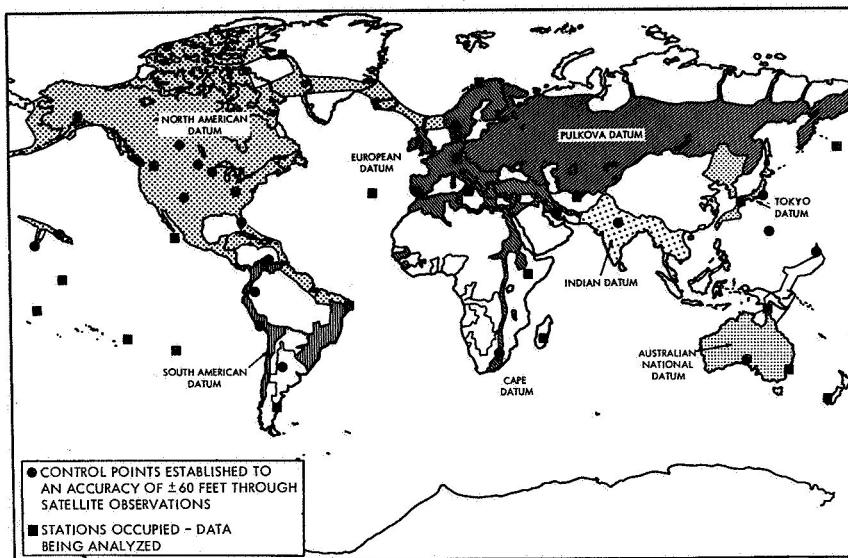


Figure 3-6. ATS-D spacecraft.

ried two C-Band radar transponders and a passive radar reflector, four optical beacons, a SECOR transponder, a Goddard range-range rate transponder, three Doppler beacons, and 400 corner cube reflectors. In addition, it carried a laser detector to measure the effects of the atmosphere on an Argon laser beam transmitted from the ground, and an experiment to measure the energy of electrons and the magnetic field in the Auroral Oval. The spacecraft was observed by all the precision electronic and optical satellite tracking systems, and its observations were transmitted to about 200 stations around the world (fig. 3-7).

#### **Earth Resources Survey Aircraft Program**

To determine what remote sensors might be flown by spacecraft to acquire data for earth resources surveys, NASA was carrying out an extensive airborne remote sensor-testing program. Various aircraft were flown over selected test sites to evaluate different sensor techniques potentially suitable for gathering information in agriculture-forestry, geography-cartography, oceanography, hydrology, and geology. Instruments aboard the aircraft were electronic and electro-optical sensors covering certain parts of the electromagnetic spectrum. The test sights were recommended by the various investigating agencies and the cooperating scientists who collected "ground truth" infor-



**Figure 3-7. Unified world reference system for the National Geodetic Satellite Program (February 1968).**

mation and compared it with airborne sensor data to find out if the sensing methods were feasible.

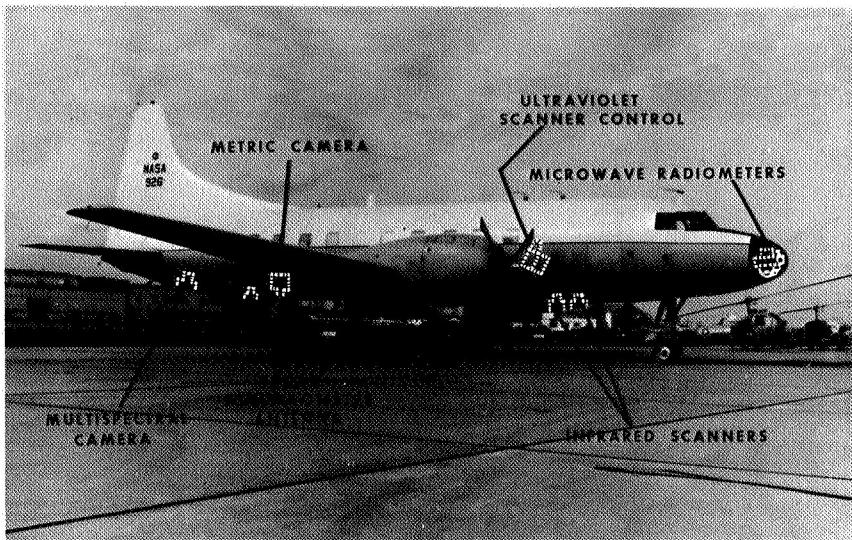
NASA used two types of aircraft in testing these remote sensor systems—one for flights up to 15,000 feet (fig. 3-8) and another for flights up to 30,000 feet (fig. 3-9). The first airplane carried infrared and ultraviolet imagers, passive microwave radiometers, a radar scatterometer, an ultraviolet to infrared multiband camera, and a metric camera. Installed in the other airplane were an infrared imager, a radar scatterometer, and two metric cameras.

From January 1 through June 30 nine flight missions were conducted over 33 test sites, as follows:

Discipline	<i>Test sites overflowed<sup>1</sup></i>
Hydrology	10
Geology	7
Oceanography	6
Agriculture	5
Geography	4
Forestry	1

<sup>1</sup> A mission usually overflies several sites gathering data for more than one discipline.

Scientific investigators were from the Navy, Commerce, Agriculture, and Interior Departments, and the National Resources Evaluation Center (Office of Emergency Planning.) Participating universities



**Figure 3-8. Earth resources survey aircraft instruments.**

included Georgia, M.I.T., Florida Atlantic, Texas A. & M., Kansas, New York, California, Purdue, and American.

To gather more information and include additional remote sensors, NASA was completing arrangements to borrow an aircraft from the Air Force to replace the airplane used in flights up to 15,000 feet. Some sensors will be transferred from the NASA aircraft to the borrowed plane and other more advanced sensors will be installed later. Initial operation of this plane—with its increased range, higher-altitude capability, and greater payload—was scheduled for the spring of 1969.

NASA also reached an agreement with the Air Force for the use of a high-altitude aircraft, which it will equip with sensors able to carry out similar missions above 40,000 feet. (Fig. 3-10.) This aircraft, assigned to the Air Weather Service, will be used by NASA on a part-time basis. Among the advantages of airborne sensor testing from high altitudes would be: extended range and coverage; greater experience for scientific investigators in handling data; provision for designing spacecraft sensors; simulation of space flight sensing without the limitations of orbiting spacecraft; and data accumulation free from the interference of 90 percent of the earth's atmosphere.

#### **Foreign Cooperative Program in Airborne Sensing**

In February, 28 Mexican and Brazilian scientists attended a remote sensing technology course conducted by the University of Michigan at the Manned Spacecraft Center, the first step in a cooperative program on airborne sensing of earth resources between NASA and

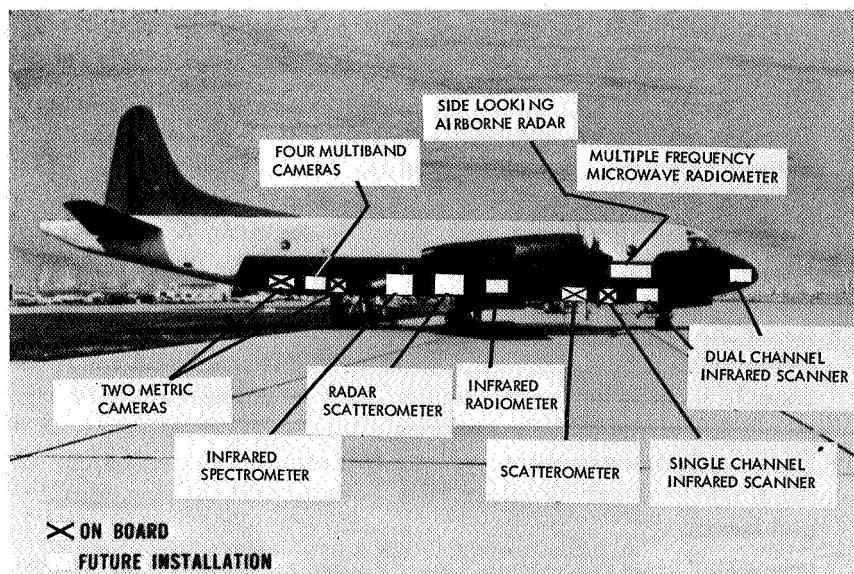


Figure 3-9. Second earth resources survey airplane instruments.



Figure 3-10. Air Force plane for NASA's Earth Resources Survey Aircraft Program.

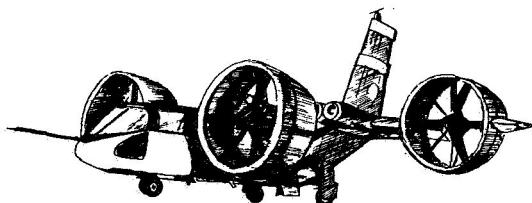
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the two countries (ch. 7). Designed to help Mexico and Brazil set up their own earth resources surveying programs, this joint project would—

- Develop techniques and systems with the cooperating foreign nations to acquire, interpret, and use earth resources data from aircraft.
- Advance the techniques and scientific methods for gathering research data in earth resources surveys to benefit the U.S. and the cooperating foreign nations.
- Assist Mexican and Brazilian scientists in acquiring, processing, reducing, and analyzing data from remote sensors, and then aid them in identifying promising applications of these data to earth resources surveys in their countries.
- Devise data management systems to facilitate the exchange of earth resources survey information between this country, Mexico, and Brazil.

After completing the remote sensor course at the Manned Spacecraft Center the foreign research scientists visited various test sites used in airborne sensor testing to gain some practical experience in this field, and the program managers from the two countries were briefed on the management of the earth resources survey program.

# 4 ADVANCED RESEARCH AND TECHNOLOGY



The activities of the Office of Advanced Research and Technology embrace a wide range of highly diversified scientific and technological investigations. Through its programs, OART provides knowledge to be used in solving key current problems and to be applied in developing future aeronautical and space vehicles. The office also coordinates all supporting research and technology. In the period of this report, progress was achieved in many research areas, and the particular projects studied are described in the following sections.

## Space Vehicles Program

### Meteoroid Protection

Spacecraft resistance to meteoroid penetration can be increased substantially by an outer wall known as a bumper. In tests to determine the optimum spacing between the bumper and the main spacecraft wall, it was found that the penetration resistance increased by at least the square of the ratio of the spacing to the projectile diameter where both the bumper and inner wall were of equal thickness. These tests were conducted with simulated stony meteoroids (small Pyrex spheres) launched into aluminum double-sheet targets at velocities up to 8.8 km/sec. Tests continued on various ratios of front-to-back sheet thickness to determine the effects of sheet thickness distribution upon penetration resistance. Data from this research on the effects of sheet thickness, spacing, and thickness distribution should make it possible to develop lighter weight spacecraft walls capable of resisting meteoroid penetrations.

**Thermal Vacuum Test Technology**

For preflight verification of the thermal balance of spacecraft, detailed knowledge of the spectrum and intensity inside the thermal/vacuum test facility is required. Instruments developed for making such detailed measurements in test facilities were carried aloft on aircraft to measure the solar spectrum and total intensity of the solar energy. The results, corrected for atmospheric absorption, indicated that the total solar energy may be about 2½ percent less than the value being used for design purposes. To verify this information by making measurements in space, plans were made for an absolute total radiation sensing instrument to be carried on the '69 Mariner mission.

**Lifting-Body Flight Program**

The HL-10 was modified on the basis of the results of its first flight, and the vehicle completed eight flights to evaluate flying qualities, particularly the landing problem, and to check out two pilots. The vehicle performed well, and the pilots equate its handling characteristics with those of some of the better fighter aircraft. Flight testing was scheduled to continue at the Flight Research Center.

The X-24A was undergoing extensive checkout and modification by the Center to bring the vehicle to flight-ready status for the first flight which should occur early in 1969. (Fig. 4-1.)

**Advanced Gliding Parachutes**

In this long-standing NASA program of research on flexible lifting devices and controllable parachutes, the first phase of a major contract effort to provide the technology necessary for the development of flexible lifting devices capable of land recovery of spacecraft weighing up to 15,000 pounds was completed. In the past six months, approximately 55 flight tests of two different NASA parawing designs were conducted. The sub-scale wings, approximately 400 square feet in area, were tested with payloads up to 500 pounds to determine the best means of alleviating opening loads and to evaluate the flying qualities of these wings. The second test phase, due to start in July 1968, will evaluate deployment characteristics and flying qualities of a 4,000-square-foot parawing with payload weights ranging up to 5,000 pounds. In-house research on a flexible lifting device (the sailwing) also continued. Part of this research consisted of flight tests on a 90-foot-span sailwing.

**Advanced Decelerator Concept**

An improved attached inflatable device for slowing down spacecraft before landing was investigated. During orbital flight, the decelerator

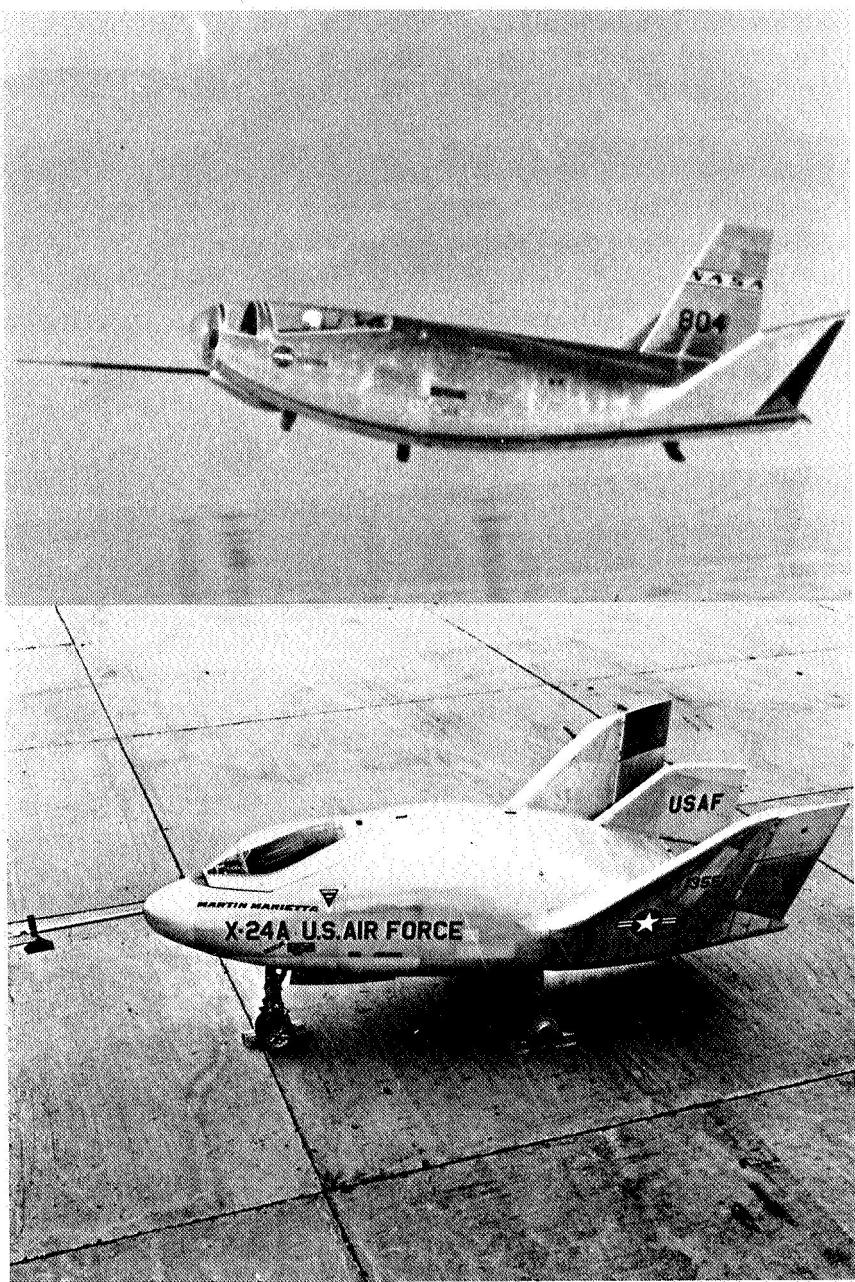
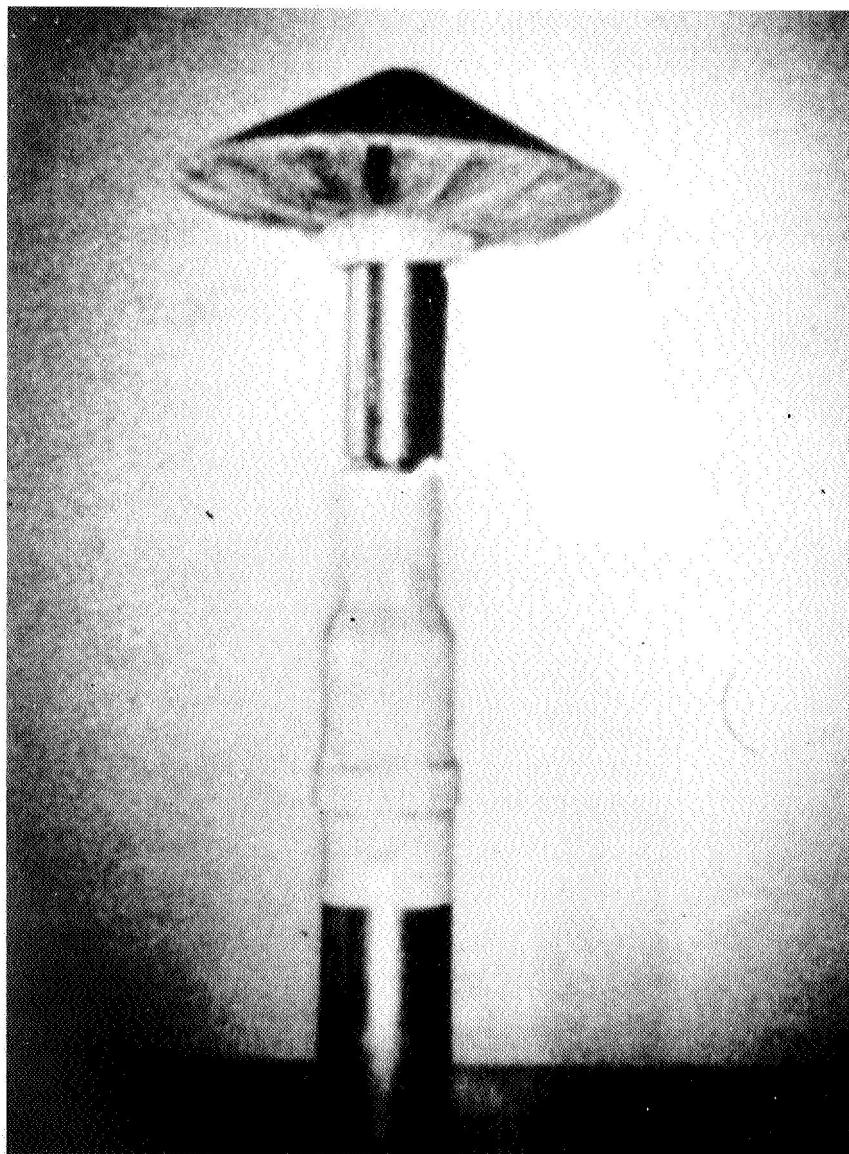


Figure 4-1. The HL-10 and the X24A.

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is stored behind or within the spacecraft body (fig. 4-2); after entry into the atmosphere, the decelerator is deployed and inflated by ram air to the shape shown in figure 4-3. The effect is to increase the drag of the spacecraft by a factor of 5.

Preliminary test results showed that the decelerator can be reliably deployed at both supersonic and subsonic speeds and that the



**Figure 4-2.** Decelerator secured to base of simulated reentry vehicle.

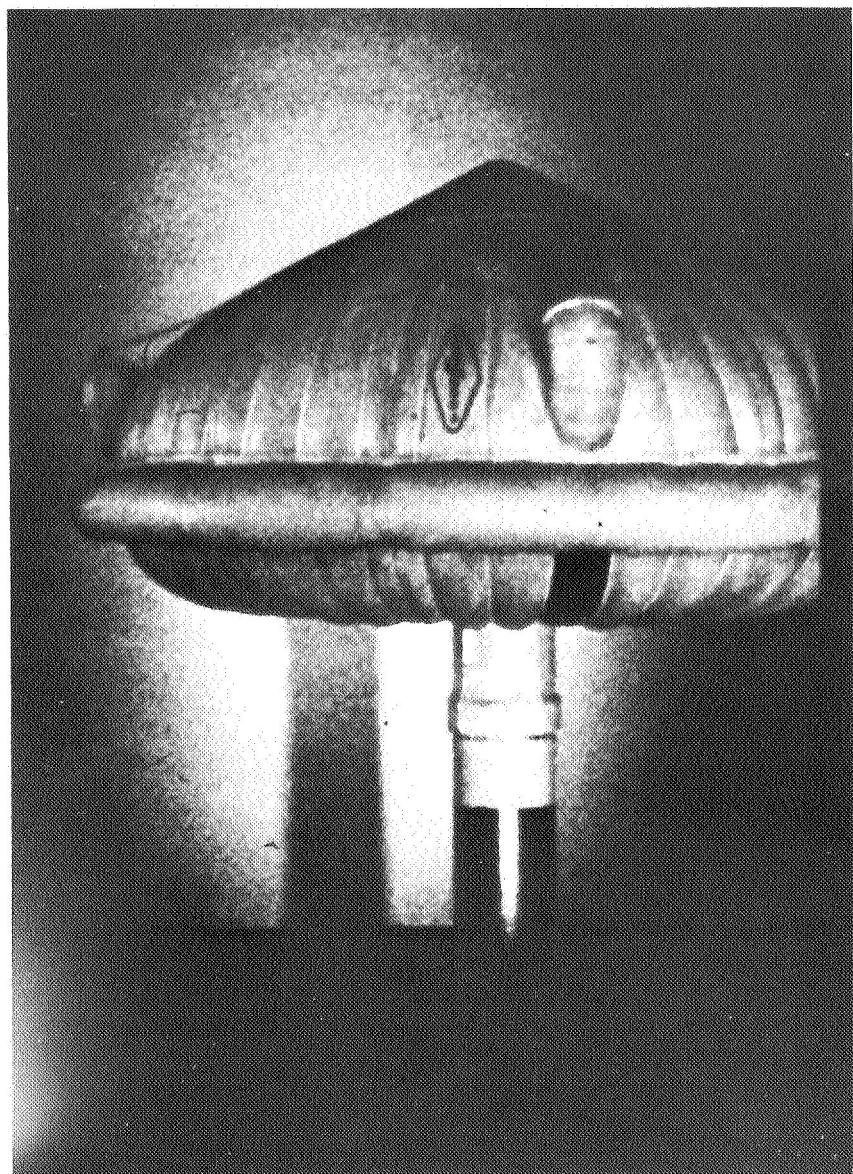


Figure 4-3. Decelerator after deployment.

spacecraft remains stable with the decelerator deployed. This concept offers a weight saving advantage over methods which employ trailing drag devices such as parachutes or balloons. Research was continued to establish technology readiness of the concept; it will include wind tunnel tests, high-altitude flight tests, and materials and design studies.

**Structural Analysis Computer Program**

This program (*17th Semiannual Report*, p. 79), now designated NASTRAN (*NASA STRuctural ANalysis*), made substantial progress. A large segment (that capable of analyzing statics problems of structures) was completed and delivered to the NASA Goddard Space Flight Center. Delivery of the complete program, which will be capable of solving thermal and dynamics problems in addition to the statics problems, is scheduled for early 1969. Other government agencies, the aerospace industry, universities, foreign governments, and industries concerned with the design and construction of ships, buildings, and bridges expressed interest in the program.

**Spacecraft Electronics and Control****Communications and Tracking**

The development of optical communication systems, which could substantially improve transmission rates for large quantities of data over great distances, is limited by lack of knowledge of the effects of the earth's atmosphere and the ability to point narrow laser beams at distant targets. In a test conducted in January, laser signals, transmitted from earth sources at Table Mountain, California and Kitts Peak, Arizona, were recorded by the Surveyor VII television camera on the moon and later telemetered to earth. The experiment demonstrated that a laser beam can be pointed through the earth's atmosphere with reasonable accuracy.

In April another advance in the development of optical communications for space operations was achieved. At that time, a laser beam was used to transmit a coded message from earth to the orbiting GEOS-2 satellite where it was received and subsequently telemetered back to earth. This transmission was the first time a laser system was used to communicate data from earth to a satellite in space.

**Control Systems Research**

In the design of control systems for precise pointing and stabilization of experiments on orbital space laboratories, one of the most important factors to be taken into consideration is disturbances caused by crew activity. Langley Research Center scientists, with contractor support, completed studies of the characteristics of disturbance forces due to crew motion. The data were developed by theoretical, analytical, and ground simulation programs, but because there were some uncertainties in the results, flight verification will be necessary. Therefore, a flight experiment plan was developed to measure the effects of certain crew motions; implementation of the flight experiment is now being studied.

### Display Devices

Computer driven cathode ray tubes (CRT's), used in modern aircraft and manned space vehicles as visual display media to present information to pilots or astronauts, are limited in display capability by an inability to maintain contrast under the high ambient illumination levels commonly found in aircraft and spacecraft cockpits. In research sponsored by the Electronics Research Center, advances were made in cathode ray tube technology which may solve this problem. In one development, an "optical diode," the CRT face absorbs incident light, and the displayed information appears in a lighter color to enhance the contrast. In the second, a technique is used whereby colored displays are generated from a single electron gun and a single phosphor layer by means of variation of the electron beam current in the CRT. The two developments will be combined to produce a simplified high contrast color CRT for cockpit displays.

### Guidance and Navigation

The concept of "Standby Redundancy" has been explored at JPL to enhance the reliability of computers. This concept, which calls for inoperative units to be switched into operation when a fault occurs on a functioning unit, was applied to a "Self Test and Repair Computer." In this computer, the switch which connects power to the standby subsystems and disconnects the faulty ones is a critical item which must be highly reliable. To satisfy this requirement, a JPL contractor developed a magnetic switch in which power is transferred by saturation of selected magnetic flux paths, thereby eliminating active components. In laboratory tests, the switches operated over a -10° to +85° C. temperature range and switched 25 watts of power.

### Instrumentation

A major advance in high vacuum measurements was achieved by the Langley Research Center with the development of a new ionization gage which demonstrated greatly improved sensitivity in measuring extremely low pressures. In preliminary tests, it performed well down to the range of  $10^{-13}$  to  $10^{-14}$  torr (one torr equals 1/760 of the earth's atmospheric pressure), an improvement of 10,000 over commercially available gages and of 100 over other laboratory gages. This device will provide the means for more accurate determination of the efficiency of vacuum pumps and the quality and cleanliness of vacuum systems which are essential for measuring trace contaminants and the out-gassing of materials in high vacuum environments.

### Data Processing

Ames Research Center developed data analysis techniques which combine the unique capabilities of analog and digital computers in

a hybrid arrangement to process large volumes of experimental data which are otherwise impractical to analyze. The new method was especially effective in extracting information from complex random and transient signals characteristic of aerodynamic noise generated in the boundary layer of supersonic aircraft, pilot control real time studies, helicopter bladeslap noise investigations, and studies of anomalies in the human heart beat. Improvement factors of 50 to 1 or more, were achieved in processing certain types of complex data.

Goddard Space Flight Center established the feasibility of applying laser and coherent optics technology to the processing of large volumes of spacecraft telemetry data. The key element is a reusable recording medium of photochromic material, which provides real time conversion of electrical telemetry signals to optical form for analysis by an optical computer. When completely developed, the new method will replace conventional photographic film conversion methods and is expected to reduce the cost and processing time by at least one-tenth.

#### **Electronic Techniques and Components**

Continued research and development work on metal oxide silicon field effect transistors (MOSFET) made it possible to fabricate devices with low power consumption and high packing densities. Both of these features are extremely desirable for space flight applications. Goddard Space Flight Center applied integrated circuits employing MOSFETs to the electronic circuitry in the Interplanetary Monitoring Platform Explorers 33, 34, and 35. The MOSFETs, which averaged about ten active devices per integrated circuit, achieved approximately 200,000 hours of successful operation in the space environment, demonstrating their feasibility as well as the possibility of using larger-scale integrated circuits. Units having 500 or more active devices per circuit are being developed for use on advanced spacecraft.

### **Aeronautical Research**

#### **Aircraft Aerodynamics**

A study was made to determine whether the large high-bypass fanjet engines for the next generation of subsonic transports will create severe adverse wing-nacelle interference. The problem was investigated in a transonic wind-tunnel with a large model of a representative transport airplane. A model jet engine in an underslung pylon-nacelle was located at various positions relative to the wing. The results indicated that both nacelle position and addition of engine power strongly influenced the interference drag (the difference between the drag for the complete airplane and the sum of the drag of its components). An increase in transonic Mach number above the design cruise value had an adverse influence on the interference drag.

### Aircraft Loads and Structures

The maneuverability and performance of aircraft at high subsonic and transonic speeds is limited by the flow separation on the wing which manifests itself in a buffeting of the airframe and large increases in drag.

To assess the various ways of solving the buffeting problem, an extensive research program was undertaken in which the effects of systematic variations in wing design parameters on buffeting tendencies were studied. The program included an investigation in the Langley high speed 7-by-10 foot tunnel to determine the buffet and static aerodynamic characteristics of a systematic wing series at Mach numbers from 0.28 to 0.94. The results indicated that, for a given Mach number, wings which display superior aerodynamic efficiency characteristics generally display the highest buffet-free lift coefficient. The findings also showed that correlations can be made between the onset of buffet and selected divergences in the static aerodynamic characteristics. Of the static elements, axial force was found to be the most sensitive to the onset of buffeting.

Studies of the susceptibility of titanium-alloys to hot-salt-stress corrosion began in 1962; interest in the problem arose from the fact that these alloys might be used as skin materials for a supersonic transport airplane operating at speeds up to Mach 3. Preliminary results confirmed the susceptibility of several titanium alloys to this type of corrosion. Consequently, an extensive investigation was undertaken with exposures up to 20,000 hours at temperatures from 400° to 600° F. It was found

- that for certain titanium alloys hot-salt-stress corrosion crack initiation can be analytically predicted over a broad range of stresses, times, and temperatures;
- that the threshold stresses decrease with an increase in exposure temperatures and time;
- that there was no stress-corrosion cracking at 400° F. for exposures up to 20,000 hours, but it developed after 17 hours at 600° F. for 50 k.s.i. stress;
- that the presence of stress corrosion cracks causes a large drop in elongation and moderate drop in tensile strength; and
- that the residual tensile properties depend only on the depth of crack, regardless of the temperature or time at which the cracks were developed.

### Aircraft Noise

As a part of a board program to reduce noise emanating from turbine powered engines, contracts were made with two engine manu-

facturers to integrate existing knowledge and new technology into an experimental turbofan engine to demonstrate potential noise reductions at the source. The initial objective of the Quiet Engine program is to demonstrate a minimum noise reduction below present turbofan engines of at least 15 PNdb (perceived noise level in decibels) during takeoff and 20 PNdb during landing approach conditions. Preliminary results of studies conducted to date indicated that fan noise reductions of about 25 PNdb on takeoff and 20 PNdb during approach appear feasible through proper design of engine components and through the use of nacelle sound absorption treatment.

Two airframe contractors were given contracts to investigate the feasibility of suppressing fan/compressor noise through the application of sound absorbent material in the engine nacelle inlet and fan exhaust duct. Nacelle acoustic treatment, which is quite flexible in application appears to be easily adopted to a wide variety of fan engine designs, reduced fan noise about 12 PNdb during ground tests with full-scale engines and nacelles.

#### **Operating Environment**

*Runway Grooving.*—In research on controlling and stopping aircraft on wet runways, laboratory tests at the Langley Landing Loads Track showed that transverse grooves in the runway surface greatly increase the tire traction and improve aircraft directional control and braking. Full-scale airplane tests at Wallops Station to assess the effectiveness of the grooves under dry, wet, flooded, and slush covered conditions used transverse grooves  $\frac{1}{4}$ " wide by  $\frac{1}{4}$ " deep, spaced 1" apart, which provided near optimum traction in laboratory tests. The results of tests with a Navy fighter aircraft and jet transport aircraft indicated that the grooves effectively improve tire-runway traction and aircraft braking and control on wet surfaces. (Figs. 4-4 and 4-5.)

Related tests were being conducted at Wallops to evaluate and correlate various devices to measure runway friction levels. Friction level is an important measure of aircraft braking performance, and a universally acceptable way of determining the friction level would enable pilots to determine the braking available regardless of the airfield location or runway surface condition. (Fig. 4-6.)

*General Aviation Technology.*—Wind tunnel and flight tests of a typical light twin-engine executive jet aircraft were being conducted to evaluate handling characteristics and pilot display requirements for this class of aircraft. (Fig. 4-7.)

#### **V/STOL Aircraft**

Wind-tunnel and flight tests were continued on a number of V/STOL concepts, including the tilt-wing deflected slipstream type.



Figure 4-4. Test landing on grooved runway.

(Fig. 4-8.) Earlier wind-tunnel tests of tilt-wing models, conducted out of ground effect, indicated that wing airflow separation would limit descent performance and cause buffeting in the low speed transitional flight regime. More recent tests, conducted in the Ames 40- by 80-foot tunnel to determine the effects of ground proximity on the aerodynamic characteristics of a large-scale, propeller-driven, tilt-wing transport aircraft, showed that ground proximity significantly reduced lift and drag and increased the nose-down pitching moment. They also revealed that aileron effectiveness for yaw control in hover diminished with decreasing ground height.

Another study conducted in the 40- by 80-foot tunnel was of a large-scale deflected-slipstream STOL aircraft typical of a conventional propeller-driven transport airplane capable of operating in and out of 1000 to 2000 foot runways. In these tests, lift coefficient increased and drag coefficient decreased as the wing tips were extended outboard. Maximum lift coefficient appeared to be limited by flow separation between the nacelles on all configurations, even though the wing tip of the high aspect ratio configuration was not protected by the propeller slipstream. Leading-edge slats controlled the progression of flow separation and extended the angle of attack for maximum lift



Figure 4-5. Examining the grooves after landings.

approximately 10°. For each wing span tested, descent capability could be improved by spanwise variation of propeller thrust. However, the spanwise variation of propeller thrust was most effective on the short span wing.

Progress was made in research on a reliable method of determining analytically the combinations of helicopter height and velocity at which autorotation could be carried out safely. Based on recently obtained FAA flight data, NASA developed a semiempirical procedure which



Figure 4-6. A friction measuring test.

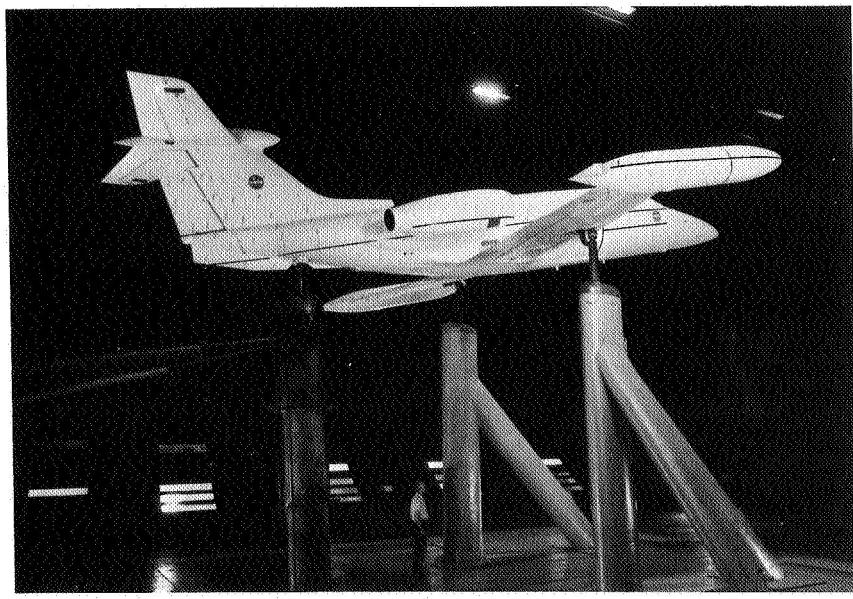
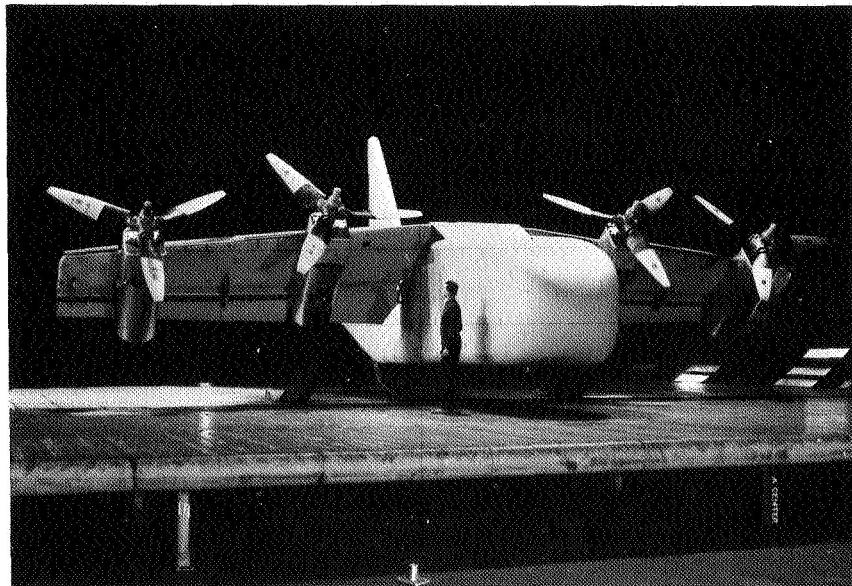


Figure 4-7. Light twin-engine executive jet.



**Figure 4-8.** Tilt-wing deflected slipstream aircraft.

shows the effects of density altitude (the altitude corresponding to a given density in the standard atmosphere) and gross weight on the height-velocity relationship for generally similar single-rotor helicopters. This method can be used during the flight testing of new helicopter designs to predict changes in autorotation characteristics. It can also be employed to predict the approximate shape of the height-velocity diagram when a helicopter is in the preliminary design stage.

Investigators at Langley Research Center studied the flying qualities and structural loads of the XH-51N during nap-of-the-earth (extremely low level and around obstacles) maneuvers (fig. 4-9) as part of a continuing flight research program on hingeless-rotor helicopters. Most of the maneuvers employed were abrupt turns, starts, and stops which require a helicopter with very good maneuverability to perform them effectively. Time histories of the rotor-limb bending moments showed that a rapid buildup in the cyclic bending moments occurs during the abrupt maneuvers. In most cases, the buildup exceeded the assigned endurance limit of the rotor hub to such an extent that the service life of the hub was significantly shortened. Thus, the indications are that any operational hingeless-rotor helicopter used for nap-of-the-earth flying must be carefully evaluated with respect to the service life of the rotor system.

The NASA study of an intercontinental supersonic transport utilizing the SCAT (Supersonic Commercial Aircraft) 15F configuration

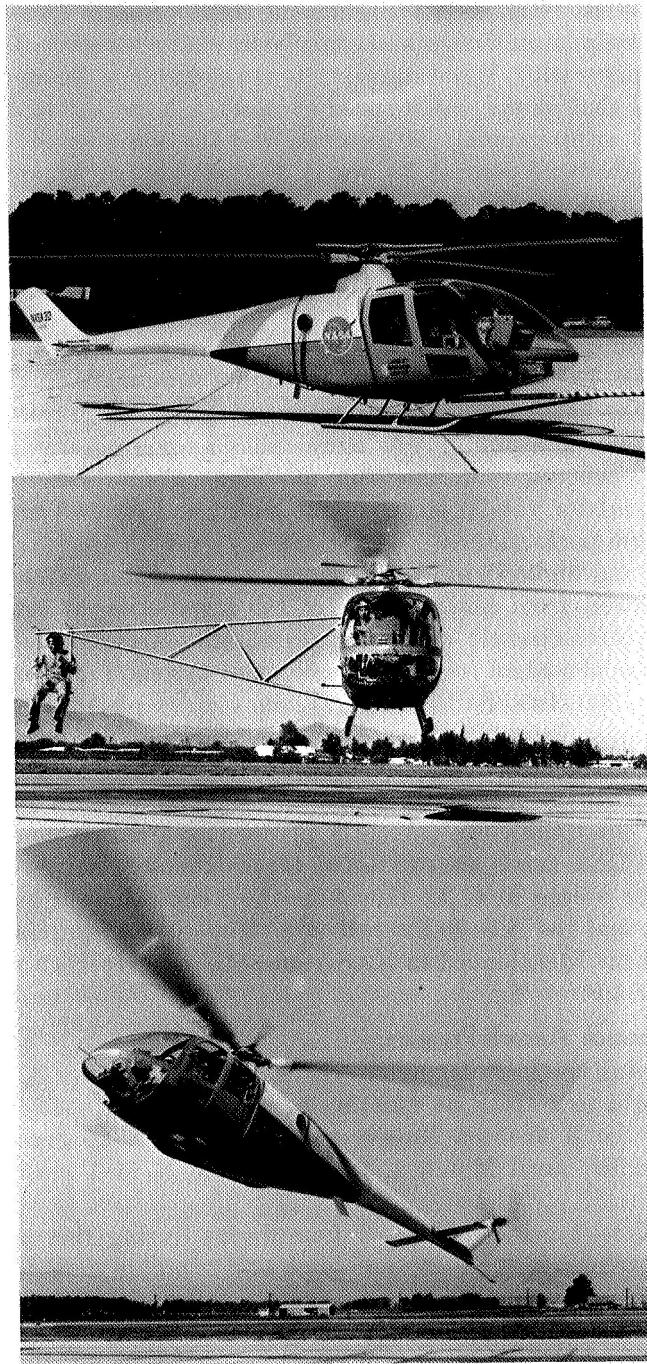


Figure 4-9. The XH-51N.

was updated. (Fig. 4-10.) Significant improvements were achieved in the aerodynamic design and sonic boom characteristics of this fixed wing configuration. Wind tunnel tests at the Langley Research Center indicated that at the cruise speed of Mach 2.7, the lift to drag ratio increased approximately 20 percent, and the sonic boom value was reduced about 25 percent, to nearly 1½ pounds per square foot. In April, NASA briefed the FAA and one of the aircraft companies on this design.

#### **XB-70 Flight Research Program**

The NASA-USAF XB-70 flight program continued with the completion of six flights in this period, making a total of 121 flights of the XB-70. Twenty-five of these flights were made in direct support of the national supersonic transport program. Major emphasis for the first four flights was again placed upon obtaining data on stability, control, and handling qualities; ground-based and airborne simulator validation; dynamic loads; and aircraft and propulsion system performance.

Following flight 73 of XB-70 Number 1 on March 21, the airplane was removed from flight status for the installation of several crew escape system changes and the research-related equipment required for the modal control (elastic mode control) system. (*18th Semiannual Report*, p. 85). Installation of the system was completed in May, flight tests began on June 11; a second check-out flight was made on June 28.

A new NASA-DOD Memorandum of Understanding for the continued use of the XB-70 aircraft was signed on May 23, and will remain in effect until the currently planned program is completed or until available funds are exhausted (approximately March 30, 1969), whichever occurs first. At that time the joint program will be terminated, and the XB-70 aircraft and all available equipment, material, and facilities loaned to NASA and the contractor(s) will revert to the USAF.

#### **X-15 Research Aircraft Program**

Following the heat damage to the X-15-2 on October 3, 1967 during a flight to a speed of 4,520 miles per hour (Mach 6.70) and the crash of the X-15-3 on November 15, 1967, all X-15 flight activity was curtailed until March 1, 1968 when the X-15-1 made its 74th flight.

The X-15-1 made a total of four flights during this period—on March 1, April 4, April 26, and June 12—to obtain data for various test-bed experiments and to check the aircraft systems, especially the electrical wiring system which was replaced following an in-flight electrical power failure on flight number 73 (June 29, 1967) which resulted in an emergency landing at Mud Lake, Nevada.

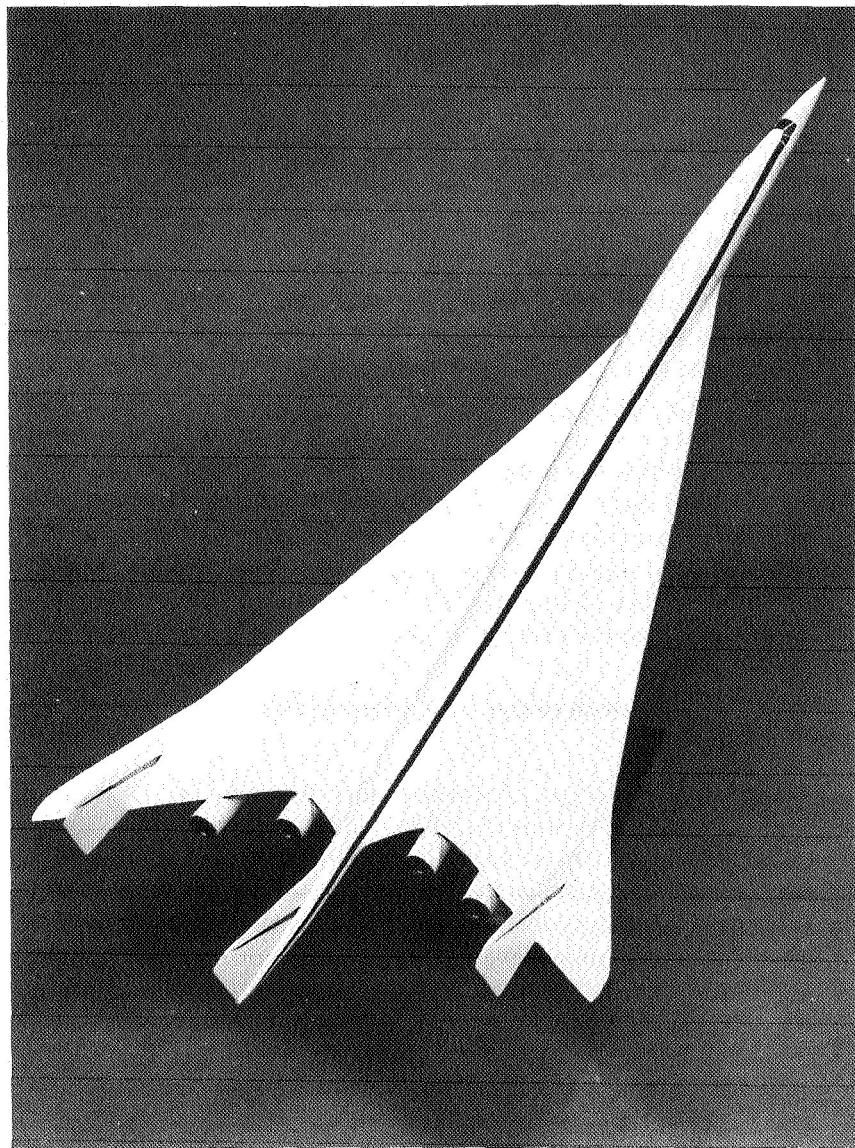


Figure 4-10. Supersonic Commercial Aircraft model.

The March 1 flight proved that the work accomplished during the eight-month down-time had eliminated the electrical problem. The April 4 flight was made to further extend confidence in all of the various aircraft systems and to obtain the initial data pertaining to the USAF Western Test Range (WTR) Launch Monitor experiment. On April 26, flight 76 was made to familiarize the pilot with X-15 No. 1

characteristics at high altitudes and to obtain data on a horizon scanner experiment in support of efforts to develop advanced equipment for project Apollo; on a new type of insulating material for large launch vehicles; and on a new fixed ball-nose suitable for measuring angles of attack and sideslip and total (dynamic) pressure for hypersonic vehicles. Flight 77, on June 12, again was made primarily for the WTR experiment, although WTR support for the flight was cancelled after the X-15 launch. The insulation being developed for launch vehicles was carried on the X-15 lower speed brakes on this flight, but the X-15 test conditions precluded obtaining useful data, and the experiment was cancelled following this flight. The horizon scanner equipment and the fixed ball-nose were carried on this flight, also.

The X-15 aircraft had made a total of 195 flights by the end of June 1968, including 150 at Mach 4 or greater, 105 at Mach 5 or above, and 4 at Mach numbers greater than 6. The maximum speed and maximum altitude attained to date by the X-15 aircraft are 4,520 miles per hour (6,630 feet per second; Mach 6.70) and 354,200 feet, respectively. Twelve flights, by eight different pilots, exceeded an altitude of 50 miles. Twelve pilots had flown the X-15 aircraft, including 5 Air Force, 5 NASA, 1 Navy, and 1 contractor pilot.

## Biotechnology and Human Research

### Advanced Concepts

An advanced prototype oculometer was delivered to Electronics Research Center by a contractor. (Fig. 4-11.) This is the first instrument available for unattached simultaneous real time measurement of such important parameters as eye movement tracking, pupil diameter, and blink rate. It is capable of automatic acquisition and tracking of the pupil/iris boundary and the corneal highlight by infrared techniques and can furnish outputs proportional to the eye pointing direction, pupil diameter, and blink rate. Pointing measurement accuracy was determined to be better than  $0.5^\circ$ . The oculometer will be used in studies to devise measures of mental alertness and also in tests to determine optimum cockpit layouts.

### Life Support Systems

In the life support systems technology program, a contractor tested a regenerative life support system in a space cabin simulator by having four men live and work for 60 days in a closed chamber. (Fig. 4-12.) The test was designed principally to evaluate life support equipment, including water and oxygen recovery subsystems. Two of the crew drank water reclaimed from urine and humidity condensate. They breathed an atmosphere in which the oxygen was reclaimed

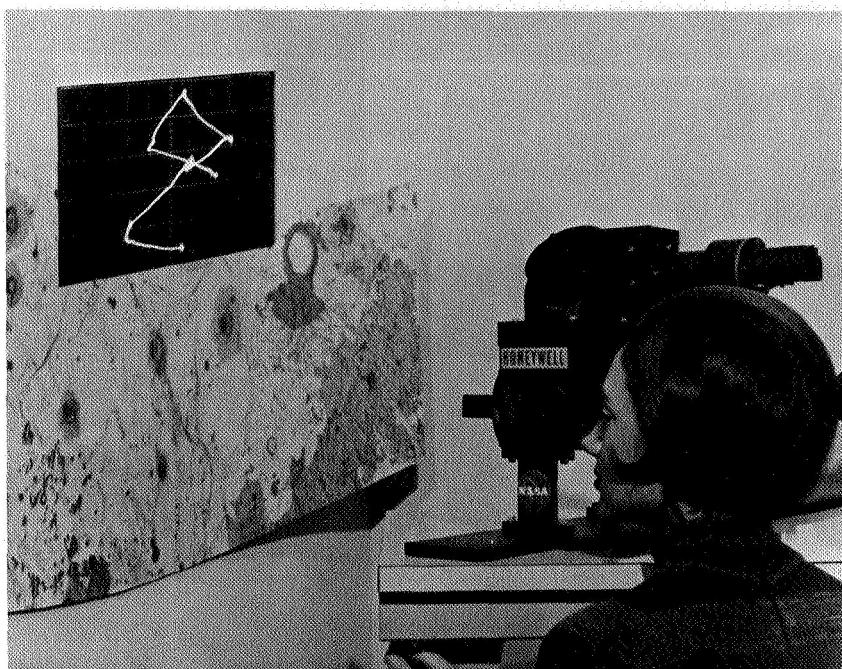


Figure 4-11. Oculometer.

from the crew-expired carbon dioxide and was free of any contaminants. The cabin pressure was maintained at 7 p.s.i.a. and consisted of 3.1 p.s.i.a. oxygen, and nitrogen as the diluent. This was the first time that men have been sustained in such a closed loop system for an extended period.

The primary objectives of the 60-day run included:

- testing the performance of a regenerative life support system comparable with those that would be found in an earth-orbiting laboratory operating on a 1-year mission with resupply at 60 to 90 day intervals;
- maintaining acceptable water potability standards with an open-cycle air evaporation water recovery system;
- demonstrating that a Sabatier reactor process (hydrogeneration of carbon dioxide) can be used in an oxygen recovery system;
- demonstrating the ability of a crew to service, maintain, and replace life support equipment within the space cabin simulator;
- and, determining the microbial profiles of crew and equipment in such a system.

Major objectives and a number of secondary aims were accomplished.



Figure 4-12. The Space Cabin Simulator.

Principal conclusions drawn from the test were that reclaiming potable water from urine and humidity condensate is practical for extended-duration space missions; regeneration of oxygen from carbon dioxide by Sabatier reaction and water electrolysis is practical; the space cabin crew can perform unscheduled repair and maintenance tasks as indicated by the performance of 47 operations, of 27 types, during the 60-day test.

#### Astronaut Protective Systems

Initial efforts were completed to combine Apollo soft suit features with shoulder and hip joint technology from the Ames hard suit system. (*17th Semiannual Report*, p. 91) The latter should provide sufficient mobility so that the new combination can be operated at the same pressure as the spacecraft, 5 p.s.i. or higher, instead of at 3.7 p.s.i., the current operating pressure for soft suits, which lack mobility at high pressures. The new suit (fig. 4-13) will offer a marked improvement in operational capability by reducing preoxygenation time for astronauts preparing to leave a spacecraft with a two gas system to perform extravehicular tasks; it will also decrease the probability of bends and increase safety after loss of cabin pressure.

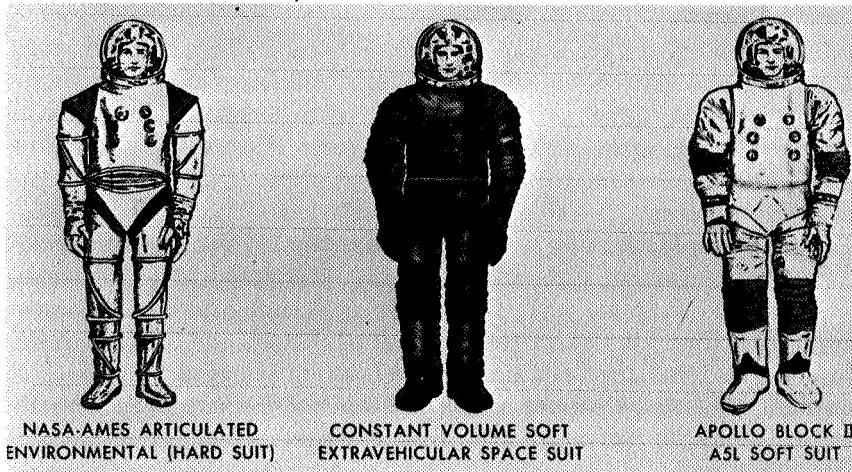


Figure 4-13. Hard suit and Apollo soft suit.

A method of astronaut cooling which does not require an external heat exchanger to eliminate body heat was being developed for the Manned Spacecraft Center. The system uses internally contained evaporative cooling patches to absorb body heat. The patches serve both as water accumulators and evaporators, accepting water from the supply tank and venting steam directly into space under controlled conditions. By getting rid of the backpack water evaporator, the water circulating pump and tubing, and the power supply, the system will decrease complexity and weight.

Research for better spacesuit materials conducted by the Manned Spacecraft Center included work on a flameproof constant-wear garment and studies of better thermal insulation. One project investigated the dermatological effects of prolonged wearing of a flameproof glass-fiber fabric (beta fiber) undergarment. The tests indicated that beta fabric underwear did not cause skin problems, but that its wearing abrasion characteristics were poor. More recently, a contractor produced a constant-wear beta fabric garment with increased durability and seam strength. Beta cloth is also being used as a flameproof outer layer for the Apollo spacesuit, in flameproof containers for various crew provision items, and as a protective covering for umbilicals.

In research on thermal insulation to protect astronauts from the temperature extremes of the space and lunar environments, studies were being conducted to develop improved materials which will be noncombustible or self-extinguishing, light-weight, low in bulk, adequately durable for extended missions, and be capable of operating in a temperature range of  $-250^{\circ}$  to  $+350^{\circ}$ F.

**Human Research**

Large solar flares are a major radiation hazard which manned space flights beyond earth orbit will encounter. Such flares eject high fluxes of protons and alpha particles capable of penetrating the walls of lightly shielded space vehicles or space suits. During this period, a technique was devised for laboratory simulation of solar flare radiation which makes it possible to assess its effects and to establish reasonable tolerance levels. The new method uses the 184 inch synchrocyclotron (of the Donner Laboratory of the University of California, Berkeley) to simulate solar flares. The cyclotron provides a narrow beam of helium ions at an energy level of 910 million electron volts. In order to irradiate a test animal the beam is enlarged by passing it through a block of copper which scatters the beam and reduces its energy to about 400 mev. This monoenergetic beam, after passing through copper, is characterized by an absorption peak at 9 centimeters depth in water. To simulate a solar flare, the beam is transformed to have such a range of energies that the dose is absorbed mainly near the surface of the test object and decreases rapidly below the surface. The transformation is produced by a "ridge filter," a device which enables investigators to achieve the desired exponentially decreasing depth dose distribution. The technique is now being used to irradiate animals in experiments to determine the combined effects of sublethal radiation and other stresses.

**Man-Systems Integration**

Studies of the physiological and psychological effects of noise on people included research to determine the threshold for auditory damage to animals, specifically to the nerve cells of the ear; subjective evaluations of the annoyance factors of subsonic aircraft to provide standards for use by government agencies, airport and aircraft operators, and engine manufacturers; and analyses of the effects of sonic booms on working or sleeping subjects which indicated that some adaptation occurs within a short time.

Another research project was concerned with the visual accommodation limitations of pilots. During low-visibility landings, pilots are hindered by the limited rate at which they can change their visual accommodation (focus) as they look from runway to instruments or from instruments to runway. An Ames contractor developed a reliable, automatic, continuously recording, infrared optometer for real time monitoring of the state of focus of human lenses. In an exploratory study, the optometer measured the rate of change of focus of five commercial airline pilots (all under 35 years of age) to a two-diopter step input (equivalent to a runway-to-instruments and instruments-to-runway change in focus). Ames will use the data to clarify and docu-

ment the individual differences in accommodation times and to investigate perceptual variables (e.g. perceived size) which may affect both the rate and magnitude of the accommodation response. This instrument may also be useful in clinical medicine and clinical research.

Under a Langley Research Center contract, investigators, using a reduced gravity simulator, studied the effort involved for man to perform physical work on the lunar surface. It was found that although less energy is required for walking on the moon, a higher energy expenditure rate is required for work involving the use of the upper torso because of the lower friction in the lunar gravity. It may therefore be necessary to design the jobs men will perform on the moon so as to reduce force requirements or provide tethers or worksite anchors similar to those needed for working in zero gravity.

In other related work, man's capacity to perform useful work in space has been shown to be quite high provided appropriate tethers and restraints are designed for his use. One study indicates that man can exert force and torque under weightless conditions if he is properly anchored to the work platform. He can also reach various work areas more readily under zero gravity than in a gravity field since it is easier to clamber about the obstructions while weightless. Marshall Space Flight Center studies of tool designs for use in earth orbit have resulted in a combined manual-motor driven wrench concept that uses muscle power to break bolts and nuts free, then uses a small (1/230th horsepower) battery driven motor to turn the bolt or nut to the disengagement point.

### **Advanced Propulsion Systems**

#### **Solid Propulsion Technology**

This program continued work on solid propulsion technology and its application to solving theoretical and engineering problems in the use of solid propellant motors. Advances were achieved in a number of areas. One resulted from research on steady-state and transient combustion theory. Here, the basic mechanisms that control the combustion termination phenomena were established and will provide the basis for development of solid motors capable of interrupted combustion and a limited number of stop-restart cycles. Another came from work on structural integrity which led to the development of failure criteria theories and equipment to measure stresses and propellant mechanical properties under various conditions. Both can be applied in the design of future motors.

Another area of progress was in the application of microwave technology to the problem of nondestructive inspection of solid motors and

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other viscoelastic materials for voids, cracks, fissures, or bond separations. This type of inspection is also applicable to many other nonconductive materials and composites; one such use is in detecting delaminations in aircraft tires which are often retreaded more than 20 times.

In a new project, fiber optics and lasers will be used in combination to ignite sensitive pyrotechnic mixes, which may be part of a pyrotechnic subsystem in a spacecraft or part of the ignition subsystem of a rocket motor. The new technique which involves the piping of laser energy by glass fibers to ignite the secondary explosive should improve ignition safety, reliability, and performance.

During this period, a third test was made of a solid propellant motor containing advanced propellant at simulated altitude conditions. Purpose of the test was to verify nozzle and insulation structure, and to demonstrate propellant performance (specific impulse) at near-space conditions. Based on the tests, a high energy motor design was established. This will subsequently be built and tested. In addition to the advanced propellant, the design calls for a system to stop combustion and then to restart it, a capability not available now to solid propellant motors in the space program.

In another area, the final preparations for a demonstration phase in the hybrid technology program were completed. Hybrid motors combine a liquid oxidizer with a solid fuel, providing much of the simplicity of a solid propellant rocket and the high energy associated with the powerful liquid oxidizer. The system proposed for evaluation will use lithium as fuel with a fluorine/oxygen liquid oxidizer. Under space conditions, the combination will produce almost 400 pounds of thrust per pound of combined fuel consumed per second, considerably better than current solid propellants. The program will test main components of a system, especially the nozzle and lithium fuel charge.

In the large solid (260") motor program, work continued on technology tasks pertaining to motor case metal, low cost nozzle ablatives, ignition, and propellant processing.

### **Liquid Propulsion Systems**

The liquid propulsion research and technology programs continued to investigate aspects of new technology, systems design, and operating characteristics with the greatest potential for improving performance and reducing costs of rocket engine systems.

Recent analyses showed that liquid hydrogen can be stored in space without venting even in small spacecraft for missions lasting 200 days. With venting permitted, or if space storable propellants are used, insulation requirements were reduced with only slight increases in

spacecraft weight. Further studies of mission tradeoffs with various propellants are being continued.

Research and experimental tests in materials compatibility associated with storage and combustion of fluorine-containing oxidizers furnished reliable data for use in the selection and design of expulsion bladders, tank linings and coatings, and combustion chambers.

Propellant research aimed at improving storability and reducing slosh dynamics and venting of the liquid propellant, included investigations of liquid/solid hydrogen, gellation of oxygen difluoride by frozen chlorine trifluoride, and gellation of diborane with a suitable frozen fuel.

In experimental work to demonstrate the performance of the tripropellant combination lithium/fluorine/hydrogen, a specific impulse in excess of 500 lbs force per pound of propellant per second was achieved. This result was nearly 10 percent better than hydrogen-oxygen propellants produce. Further efforts will be directed toward minimizing the inert weight and size of this engine system.

The combustion instability program acquired additional data on the use of baffles and liners to control combustion instability. The new information provides a rational explanation for some previous baffle and liner failures; it also will be the basis for design criteria for future engine applications.

The advanced launch vehicle engine experimental program produced new high performance engine segments which offer the advantage of reduced combustion chamber size and consequent lighter weight for a modular plug nozzle engine. This modular approach to engine design also promises reduction in development costs for new large engines.

The space-storable propellants under investigation for use in future spacecraft moved closer to readiness. Testing of the methane-fluorine-oxygen combination in a fuel-cooled thrust chamber was successful, and work was initiated to provide small turbine pumps for this type of engine. Carbon-based, ablation-cooled thrust chambers tested with diborane and oxygen difluoride showed excellent durability with this high temperature propellant combination. Work will continue in this area. In support of the space storable propellant investigations, the first tests of small attitude control thrusters using the methane-fluorine-oxygen propellants were conducted.

The fluorine-hydrogen propellant combination reached the point of substantial readiness for use in high energy space applications. Testing of modified RL-10 oxygen-hydrogen engines with fluorine-hydrogen propellants gave good results. The results, coupled with studies of other system components, indicate significant performance improvement over existing systems, and suggest that it would be

appropriate to commit this highest-energy chemical bipropellant system to development. Related research on the toxic effects of fluorine-based propellants resulted in more information on the tolerance of men, animals, and plant life to these compounds. One finding was that the standard for human tolerance to fluorine could be increased fivefold. Studies of the effects of accidental spillage and methods of contamination control were used to develop standards for the safe handling of fluorine in the test and launch site environment.

Investigation of low-thrust chemical systems to replace high pressure stored gas (which adds weight and volume to the system) for auxiliary propulsion was continued. Several techniques for storing liquids at low pressures and converting them to a gaseous state to provide precise thrust increments were in the experimental stage. Gas sources tested included chemical and electrical decomposition products of liquid hydrazine.

### Basic Research

#### Fluid Physics

*Aerodynamic Noise.*—A research program was initiated to acquire sufficient understanding of the basic mechanisms responsible for sound generation by supersonic exhausts so as to describe the phenomenon with a theory that permits scaling from laboratory experiments to engine exhausts. In addition the program will seek to modify the exhaust flow constructively to reduce noise. Progress was made in both tasks. Preliminary experiments indicated that the noise level is reduced significantly by using a shroud to induce in the jet exhaust a secondary flow which converts the exhaust from supersonic to subsonic without loss in thrust.

*Sonic Boom.*—Advances were made in research on the theory of sonic boom generation and propagation for maneuvering aircraft in nonhomogeneous atmospheres; also, exotic configurations were investigated for supersonic aircraft. Preliminary results indicated that if the lifting surface is extended to the front of the fuselage and wing-body-engine interference effects are used properly, significant reductions in sonic boom can be achieved. For example, conventional supersonic configurations could conceivably be modified in accord with the above results to reduce the sonic boom over-pressure by about half without penalizing the lift/drag ratio of the aircraft at cruise.

#### Applied Mathematics

*Numerical Techniques.*—Mathematicians at Marshall Space Flight Center significantly improved procedures for numerical integration of differential equations (such as the equations necessary for calculating possible earth-moon trajectories) to be used for programming computers. The procedures developed at Marshall were tested on such a

trajectory problem against a standard classical method. The results were more accurate by the new Marshall methods, and in addition they were achieved in a fraction of the time required by a good standard method. Since many thousands of such experimental trajectories must be computed annually at the Center, the total saving in computer time cost at Marshall on this one problem alone was at least \$300,000 a year.

### Materials

*Fire Suppression.*—The Ames Research Center, by applying principles which it established to protect reentry vehicles from aerodynamic heating, developed plastic materials which provide fire protection. In one case polyurethane foams were modified with alkyl halide resins, inorganic salts, and encapsulated halogen-bearing molecules to produce a self-extinguishing and thermally insulating material. The Center also developed an intumescent paint which, when activated by heat, expands to form a thick, low density coating that protects the substructure to which it has been applied. Both materials, which are easily applied to existing vehicles, provide effective protection against the destructive action of fuel-fires.

*Microwave Crack Detector.*—Investigators at Ames discovered an easy to use, nondestructive method for detecting cracks in metallic surfaces. The technique uses high frequency radio waves (microwaves) directed toward a metallic surface; the presence of a crack is revealed by detecting the reflected microwave energy. The new technique is convenient, noncontacting, and already as sensitive as currently used nondestructive methods. Efforts were continued to further develop the potential of this method to increase the sensitivity of flaw detection.

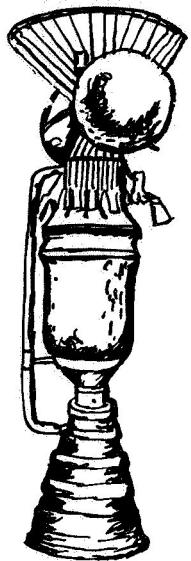
*Photoconductivity.*—Scientists at the Langley Research Center conducted research on new methods for analyzing the properties of the defects in cadmium. Since the characteristics of photoconductors are largely dependent on the presence of defects in their crystal structures, greater knowledge of these properties should make it possible to improve the efficiency of these materials. In the method under study, a beam of white light (from a tungsten lamp) and laser radiation were simultaneously passed through a CdS crystal. When the white light was used alone, absorption occurred in specific wavelength regions of the spectrum; when laser radiation was added, the absorption pattern was unexpectedly modified. The change in absorption is believed to be due to a hitherto undiscovered ability of the defect centers to be modified. The new effect, called LIMA for (*Light Induced Modulation and Absorption*) should yield new information regarding the nature of defects and should ultimately lead to the development of more efficient photoconductors.

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**Electrophysics**

*Miniature Pressure Transducer.*—During research on the effect of pressure on the energy levels of semiconductors used in electronic communication systems, it was found that a gallium antimonide crystal had outstanding characteristics as a transducer for converting pressure variations into corresponding electrical signals. As a result, a device was fabricated which was small enough to be inserted into the artery of a dog to record the cardiovascular pressure. It is anticipated that this device can also be used to sense the very small changes in acceleration and pressure in space flight.

*Structure of the Arc Discharge.*—Arc discharges are essential subsystems of magnetohydrodynamic type gaseous plasma power generators and electrical propulsion engines both of which have great potential for spacecraft use. In research on the mechanisms by which the flowing working gas interacts with the arc discharge, it was found that the arc discharge in a cross-flow configuration consists of a pair of counter-rotating plasma vortices about which are both a viscous and a thermal boundary layer. The working gas receives its momentum through the viscous boundary layer, and the thermal boundary transmits the heat. From this new knowledge of arc-gas interactions, it should be possible to improve designs for plasma generators and accelerators.



# 5

## NUCLEAR SYSTEMS AND SPACE POWER

Through the nuclear rocket program, work continued to move toward the achievement of the four key goals, with the primary objective being the development of the 75,000-pound-thrust NERVA engine. Major components of the 35-50KW SNAP-8 power conversion system were further tested, nuclear electric power research and technology efforts received continuing stress, and work in the area of space power technology pressed for significant advances in developing space electric power systems.

### The Nuclear Rocket Program

The nuclear rocket program, a joint endeavor of the National Aeronautics and Space Administration and the Atomic Energy Commission, is intended to provide a significant increase in propulsion capability for future space activities. The program has four key goals: to provide the basic technology for nuclear propulsion systems, to develop a NERVA engine of approximately 75,000 pounds thrust for flight applications, to extend the technology of graphite reactors and engine system components as a basis for improving nuclear rocket performance, and to investigate advanced concepts.

During this period, the program made substantial progress toward completing the technology goals. Engineers and scientists completed the tests initiated in the latter part of 1967 on the cold-flow ground-

experimental engine (XECF) in Engine Test Stand No. 1 (reported in *Eighteenth Semiannual Report*). They also completed the hot tests of the Phoebus-2A reactor, the most powerful nuclear rocket reactor ever operated, at the Nuclear Rocket Development Station in Nevada (NRDS). In addition, significant advances in fuel-element technology were made and demonstrated in laboratory tests. These advances indicate that much longer operating durations can be achieved.

Preliminary work on the design of the NERVA engine continued. This work makes use of the output of the NERVA technology program. Also continued were efforts to define facility modifications required to test the NERVA reactor and engine (using the existing facilities at NRDS). Test Cell "C" is to be used for all reactor testing. NERVA engine testing is to be accomplished in Engine Test Stand No. 1 now being activated for the first "hot" tests of the NERVA ground-experimental technology engine.

#### **Status of Reactor Technology**

Most of the goals established for the reactor technology phase of the program were achieved when the NRX-A6 reactor completed its full-power endurance test (December 1967). Additional goals included exploring increased specific impulse and power density and scaling up the reactor system to higher power levels.

With the test of the Phoebus-2A reactor and the significant advances made in fuel-element technology, all of the remaining reactor technology goals were satisfied.

*Phoebus-2A Reactor.*—The Phoebus-2A reactor (Fig. 5-1) was the twelfth nuclear rocket reactor to be tested at NRDS. Designed and developed by the Los Alamos Scientific Laboratory, the Phoebus-2A also was the most powerful nuclear rocket reactor ever to be tested at NRDS.

The Phoebus-2A test program was originally planned to demonstrate high-power reactor performance for direct application to the 200,000 pound thrust NERVA-2 engine. When the proposed NERVA engine thrust level was reduced to 75,000 pounds, the Phoebus-2A no longer had this purpose. It remained a useful tool, however, for demonstrating higher power density and for obtaining data on reactor design concepts being considered for use in the 75,000 pound thrust NERVA engine. The Phoebus-2A test program also included experiments for obtaining data relating to a new method of reactor control.

The major experiment of the Phoebus-2A test program was conducted on June 26, 1968. The reactor was operated for about 32 minutes at significant power, about 12 minutes of which were at a power level above 4000 megawatts. The peak power reached was about 4200 megawatts. The test was terminated as planned when the dura-



Figure 5-1. Phoebus-2A Reactor Test (June 26).

tion limits set by the available propellant and water storage were reached. Additional experimentation at intermediate power was being planned. Analysis of data from this experiment was in progress at period's end.

*Fuel Element Materials Research.*—The initial duration objective for nuclear rocket fuel elements was achieved in December 1967 when the NRX-A6 reactor was operated for 60 minutes at full power (approximately 1100 megawatts). (The NRX-A6 reactor test program was described in the *Eighteenth Semiannual Report*.) Emphasis in

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fuel-element materials research then shifted toward cyclic testing and testing at higher power densities and temperatures.

Laboratory tests of improved fuel elements have provided test durations of more than 100 minutes with reasonable corrosion results. These tests were conducted at temperatures much higher than achieved in the NRX-A6 reactor. The substantial impact of high specific impulse on space vehicle performance makes increased-temperature reactor operation most desirable. Improved high-temperature fuel-element performance is therefore a constant goal.

As described in the *Eighteenth Semiannual Report*, the program for improving fuel-element performance uses electrically heated corrosion furnaces for corrosion testing. This mode of testing however must be checked periodically through full-scale reactor tests at NRDS. Investigations at Los Alamos have made it apparent that a smaller-sized reactor, requiring a smaller number of fuel elements would be the most economical approach to satisfying this requirement. As a result of LASL's investigations two such reactors, the Pewee-1 and Pewee-2, were being fabricated.

The Pewee-1 reactor was in the final stages of assembly, with testing scheduled for the fourth quarter of 1968. The minor modifications to Test Cell "C" required to meet Pewee test conditions were defined, and the work to incorporate these modifications was scheduled to follow the Phoebus-2A test program.

The test schedule and objectives for Pewee-2 reactor test reactor were being defined.

### **Status of Engine System Technology**

The nuclear rocket program continued to stress completion of the engine system technology effort and the NERVA flight engine development activities.

The principal objective of the engine system technology effort is to accumulate data and experience on which to base development of the NERVA flight engine. Most of the work that remains relates to testing the hot XE ground experimental engine in Engine Test Stand No. 1. Assembly of this engine was largely completed during the period. Most of the engineers and scientists responsible for this XE design and development effort were transferred to the NERVA engine design work.

*The XECF Test Series.*—The most significant accomplishment in the engine system technology program during the period was the conduct of the XECF (experimental engine, cold flow) test series in April. This was the first time a nuclear rocket engine had been tested in the new test stand, ETS-1, in a downfiring position. (Fig. 5-2.) The major objectives of the series were to verify that ETS-1 was ready for hot

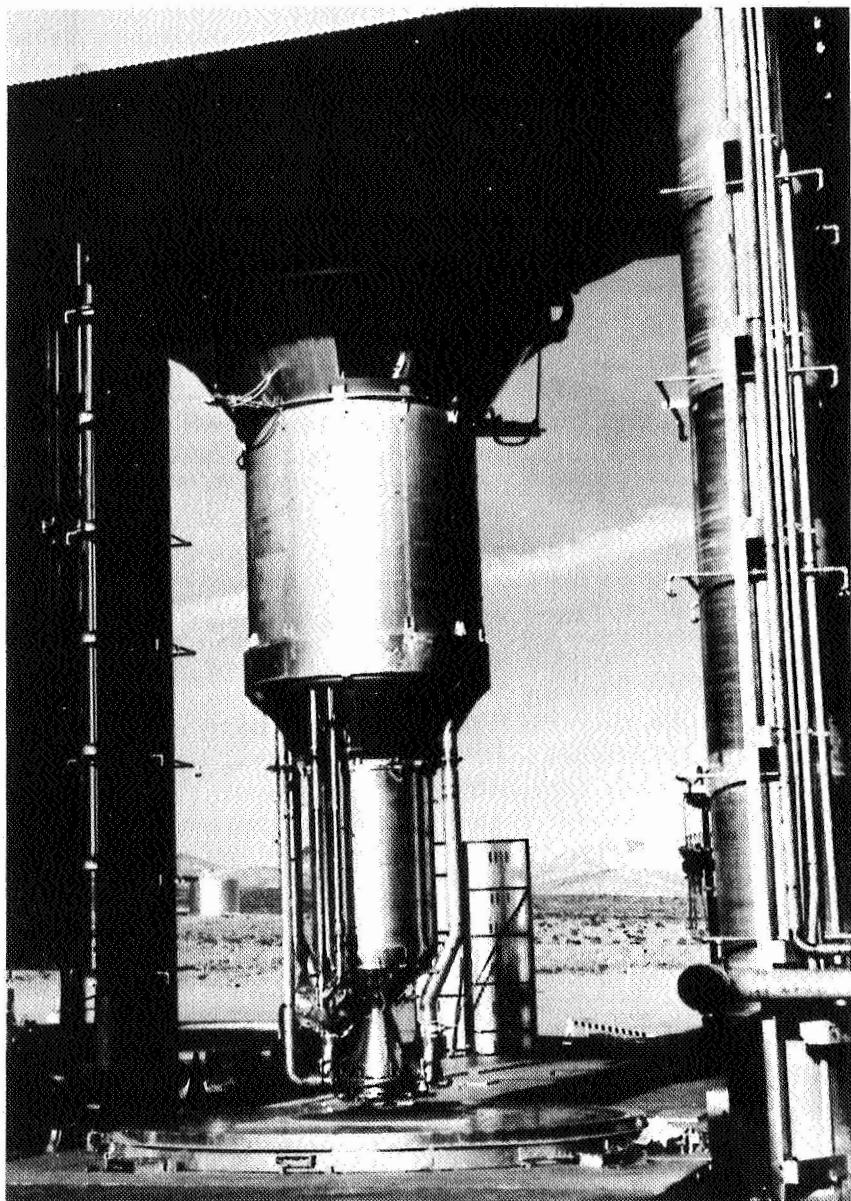


Figure 5-2. Cold-flow ground-experimental engine in Engine Test Stand No. 1, NRDS, Nevada.

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engine testing, and to investigate engine bootstrap startup in the test stand under simulated altitude conditions. Other objectives included checking operating procedures that had not been demonstrated in previous tests, and investigating engine malfunctions under simulated conditions.

The XECF test series was successful—that is, all primary test objectives were met. All systems operated as intended, and smooth engine bootstrap startups were achieved at the planned test conditions. As might be expected, engine and facility anomalies were discovered which must be corrected before hot tests of the ground experimental engine are begun.

*Engine Test Stand No. 1.*—Engine Test Stand No. 1 was qualified to receive the first "hot" ground-experimental engine. Additional facilities work and testing remains to be accomplished, however, to take care of problems found in the course of the XECF test program. Also, it is necessary to check out those facility systems which could not be qualified under the partial flow and pressure conditions of the XECF test program (such as the nuclear exhaust and emergency cooldown systems). All stand work should be completed by the fall of 1968.

### **Status of NERVA Development**

The objective of the NERVA development effort is to provide an engine of approximately 75,000 pounds thrust, with a specific impulse of 825 seconds, with the capability for multiple restarts in space, and with the highest possible reliability. Such an engine should provide the capability to perform a wide variety of missions—missions of the type that a viable space program will encompass.

In the *Eighteenth Semiannual Report*, it was indicated that the preliminary planning in preparation for the development of the 75,000 pound thrust engine had been completed. However, early in this reporting period, this planning was expanded into a development schedule, thus indicating that preliminary flight tests for the NERVA engine, based on current NERVA and Phoebus reactor technology, could be accomplished in 7 to 8 years.

In addition to NERVA planning and scheduling activities, work continued on the preliminary design of the NERVA reactor and critical engine hardware such as the nozzle and nozzle hot-bleed port, reactor pressure vessel, and turbopump. Concurrently, work continued on the preliminary design of modifications required to test the NERVA engine at full-power and under simulated flight conditions in ETS-1.

### **Advanced Nuclear Rocket Concepts**

The objective of the nuclear rocket program's advanced concepts work is to assess the feasibility and performance potential of certain

advanced concepts whose theoretical performance exceeds that possible in the solid core nuclear rocket.

Most of the advanced concepts work continued to be directed toward the nuclear light bulb concept of the gas core reactor. Even though this concept introduces some extremely complex materials problems, it is favored over other gas core concepts because it offers the potential of complete fuel containment. In the first half of 1968, tests were concentrated on developing and containing a high-temperature-high-heat flux plasma to simulate the thermal environment of the nuclear light bulb.

Experimental and theoretical work also continued on a second advanced concept, coaxial flow. Initial work has shown that further analysis of the basic flow parameters is necessary.

### The SNAP-8 Development Project

NASA continued the endurance development of major components of the 35-50KW SNAP-8 power conversion system in both a breadboarded power conversion gas-heated system loop and various component loops. Testing of the turbine, previously reported as inspected at 2,122 hours, continued to more than 3,500 hours without indication of difficulty. Further efforts were made to develop a new boiler design which uses tantalum to correct a previously observed corrosion problem. The first full scale boiler using tantalum is shown in Fig. 5-3. This boiler and additional part-scale boilers are being tested and evaluated.

Life evaluation testing of the other major components was continuing satisfactorily. A second pump, used in the high temperature reactor loop, passed 10,000 hours of demonstrated life. In the area of power conversion system technology, investigation of the startup characteristics of a breadboarded system was begun.

### Nuclear Electric Power Research and Technology

Experimental and analytical programs aimed at providing the data needed to evaluate various advanced nuclear power system concepts were stressed.

#### Rankine Turbogenerator Technology

The three-stage potassium vapor turbine containing refractory metal components was placed on test on May 13. Startup and operation were smooth, and a complete performance map was obtained in only 2½ days of operation. The tests showed excellent agreement between experimental and predicted turbine efficiencies and about a 3 percent discrepancy between measured and predicted potassium flow rates. Endurance testing with 10–13 percent potassium moisture content was

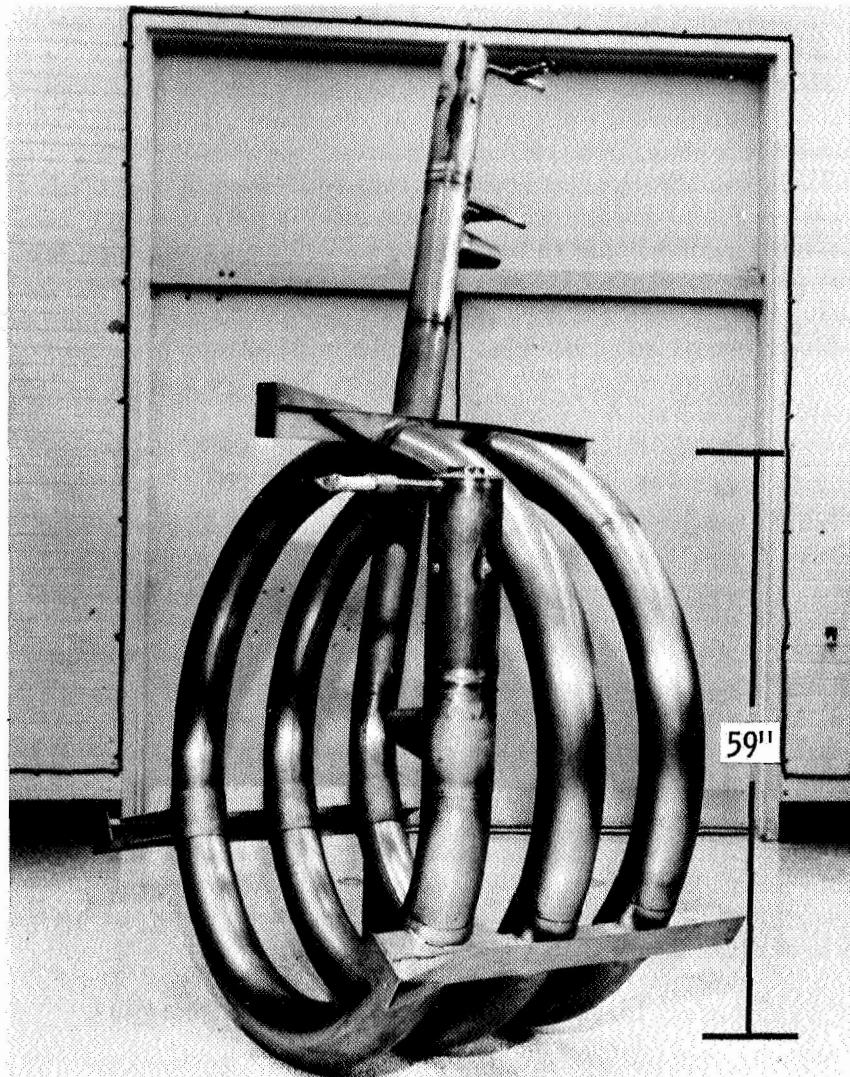


Figure 5-3. First SNAP-8 tantalum/stainless steel boiler.

initiated May 15, proceeded to June 17, was then stopped for repair of a valve leak, and was resumed on June 24. This was the first time that a potassium turbine has been operated under conditions of a space power turbine.

A conceptual turbogenerator design study was completed, and a preliminary design study of two candidate machines was started. These designs are aimed at a 3- to 5-year life and a turbine efficiency of 81 percent. This potassium design study, incorporating the results of all

prior work on the Rankine system, should provide the basis for a technology program on full-scale turbogenerators.

A lithium-heated potassium boiler (in which potassium flows across tubes) showed excellent stability under severe testing. A 100-hour hands-off system stability test was successfully completed. Arrangements were underway for further investigations on this boiler concept at the Lewis Research Center.

High temperature (1,100° F.) electrical and mechanical tests were successfully completed on a full-scale stator model of the boiler feed pump. Progress was made in the program to develop a capability for a 300° F. higher coolant temperature by use of higher temperature braze material.

#### **Thermionic Conversion Technology**

The output power of a thermionic converter improves with increases in emitter work function, although the latter is highly dependent upon the crystal faces of the exposed emitter material. The highest work function for tungsten is achieved for the 110 crystal plane.

Recently scientists found that tungsten surfaces with predominantly 110 orientation could be produced by the chemical vapor deposition method. As a result of this finding, the investigators conducted experiments to produce these "preferred-oriented" tungsten emitters and to determine whether they would be metallurgically and crystallographically stable at the high temperatures and for the long periods required.

During this report period, the investigators made considerable progress in understanding the deposition process variables and in determining the high temperature, long term behavior of the "oriented" emitters. A series of 1,000-hour tests at temperatures near 1,800° C. revealed no changes in work function. Some metallographic changes, however (particularly with respect to grain growth), were observed. At period's end, programs were in progress to find ways to impede this grain growth and also to assess the potential of duplex emitter structures. Many other experimental programs continued, producing important data since the last reporting period.

#### **Brayton Cycle Technology**

The Brayton program continued as a combined in-house and contract effort. It emphasizes experimental verification of component and subsystem performance since the overall efficiency of the Brayton power system is very sensitive to such performance. Testing at NASA Lewis on the small (4.5-inch diameter) research radial-flow compressor and turbine packages indicated that the efficiencies of both units are higher than was expected. Design-point efficiencies of 82 percent for the com-

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pressor and 91 percent for the turbine were achieved. Off-design performance testing of these units was in progress.

Two gas bearing mounted units were tested. A turbo-alternator unit operated satisfactorily at design conditions for more than 700 hours towards a 1,000 hour scheduled test, and a radial-flow turbo-compressor package recently began operation. This latter unit has a re-designed bearing support system. The first prototype "Single-shaft" turbo-alternator-compressor gas-bearing-mounted unit will be delivered in the summer of 1968 for testing at Lewis. Design operating conditions for this unit are 1,600° F. turbine inlet temperature and 36,000 rpm rotative speed.

Subsystem contracts were negotiated for such items as the control system for the complete power conversion loop, the "gas management" startup-restart system, and additional advanced design heat exchangers. Delivery of these units for in-house testing should begin during the latter half of 1968.

### **Isotope Power Systems**

The SNAP-19 units for the Nimbus B were qualified during this period by the AEC and delivered to NASA. They were launched on the Nimbus B spacecraft on May 18, 1968, but the mission was aborted by the range safety officer because of a booster guidance malfunction. The spacecraft containing the SNAP units impacted into the ocean off San Miguel Island near the California coast. As expected, radiation surveys of the area were negative because the fuel is completely contained within the capsule.

Studies of the isotope reentry vehicle (IRV) for the Brayton system were proceeding well. Verification testing of the more promising intact reentry body configurations was performed at Ames Research Laboratory. Lewis Research Center is directing the overall effort, with a contractor having responsibility for this initial portion of the IRV study.

The 50-watt SNAP-27 power system for the Apollo ALSEP was proceeding satisfactorily. Extended life and lunar day/lunar night tests were nearing completion. Delivery of all equipment is expected to be made substantially on schedule.

Goddard Space Flight Center personnel made important advances in thermoelectric technology. The degradation mechanisms (loss in performance with time) for lead telluride thermoelectric elements were identified and methods for minimizing degradation and for predicting degradation rates for various operating conditions were established. In addition, work on cascaded elements resulted in the development and demonstration of successful techniques to bond both of these thermoelectric elements to tungsten shoes. These cascaded

elements were found to be stable and to deliver the predicted high performance.

### The Electric Propulsion Program

The Electric Propulsion Program continued to advance the system technology toward possible mission applications in the areas of auxiliary and prime propulsion. Resistojets and ion engines appear to be attractive for satellite control functions (station-keeping, for example) because of their very low thrust capability, ability to vector thrust electrically instead of mechanically, and their lower weight as compared to competing chemical auxiliary propulsion systems.

Prime propulsion of interplanetary spacecraft by ion thruster systems powered by solar cell arrays is another attractive possibility for electric propulsion. In general, mission studies have shown that smaller, less costly launch vehicles can perform a specified mission when electric propulsion is used. Alternatively, an electrically propelled spacecraft can transport a larger payload to a given target.

#### Auxiliary Propulsion

As reported previously, a resistojet and a contact ion engine were scheduled to be launched aboard Applications Technology Satellites (ATS)-D&E. Operating with ammonia propellant, the resistojet system will produce 50 micropounds of thrust to provide the required East-West station-keeping for these satellites. The ion engine, with a nominal 10-micropound thrust level and the capability to vector thrust electrically, will be flown as an experiment. Both of these flight systems were integrated into the ATS-D spacecraft, scheduled to be launched in mid 1968. (The ATS-D was launched August 1968.)

A recently completed study indicated that high specific impulse resistojets (300 to 700 seconds) designed for 10-millipound thrust levels are extremely attractive for position control of manned orbiting vehicles. As reported in the *18th Semiannual Report*, these types of resistojets were scheduled for life testing. The endurance tests were begun, and thrusters operating on ammonia and hydrogen had operated successfully for more than 1,500 hours at period's end. The tests were continuing.

#### Prime Propulsion

The planned SERT II orbital flight test scheduled for a 1969 launch represents a significant step in the development of thruster technology. It is intended to demonstrate long term (6 months) space operation of a 1-kilowatt mercury electron-bombardment thruster. The effort has progressed to the point where operation and checkout of an integrated experimental system including the spacecraft, spacecraft support unit,

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thruster and power conditioning have been initiated. Prototype subsystems were being fabricated, with subsequent testing of these units being scheduled.

A second major activity was being directed toward a ground test of an ion engine system to demonstrate the feasibility of such a system to perform all the operating functions required for a typical mission application. After the preliminary performance tests on the 2.5-kilowatt thruster modules were completed, as reported in the *18th Semiannual Report*, an effort was undertaken to design and fabricate the power conditioning subsystem. A failure logic and switching system was designed and procurement started, and actuators for thrust vector alignment were developed. All aspects of this activity were on schedule, with open loop testing to start in the first half of 1969.

### Space Power Technology

Research during the reporting period continued to advance space electric power systems using solar and chemical energy sources.

#### Solar Power Generation

Large area (3-in. x 3-in. and larger) CdS thin film solar cells have a potential for important cost savings over the small (0.8-in. x 0.8-in.) silicon solar cells now used on U.S. spacecraft. However, the CdS solar cells suffer from two major defects—performance degradation with time, and low efficiency. Since 1962, NASA has conducted research on CdS cells with a goal of understanding and, if possible, correcting these defects. A new solar cell design has evolved. A 0.001-in. CdS film is evaporated onto a 0.0013-in. electrically conductive plastic (Kapton) substrate. A thin copper sulfide barrier layer is formed by dipping the CdS film in a heated water solution containing dissolved copper chloride. The resulting semiconductor junction between P-type copper sulfide ( $Cu_2S$ ) and N-type cadmium sulfide (CdS) produces an internal electric barrier which acts to separate negative and positive charges generated by incident sunlight. (Fig. 5-4.) If low resistance metal contacts are made to the P (positive) and N (negative) sides of the device and connected to an external load, the action of sunlight will cause an electric current to flow.

Progress was made in understanding the performance degradation with time. Moisture must be excluded from the barrier region. In the present cell this is accomplished by attaching a plastic cover over the barrier with a thin, transparent epoxy adhesive. Attachment of low resistance metal contacts (an open grid-like mesh is used to cover the sunlight side) is still difficult and further improvements are needed. Temperatures above 100° C. cause rapid degradation of present cells

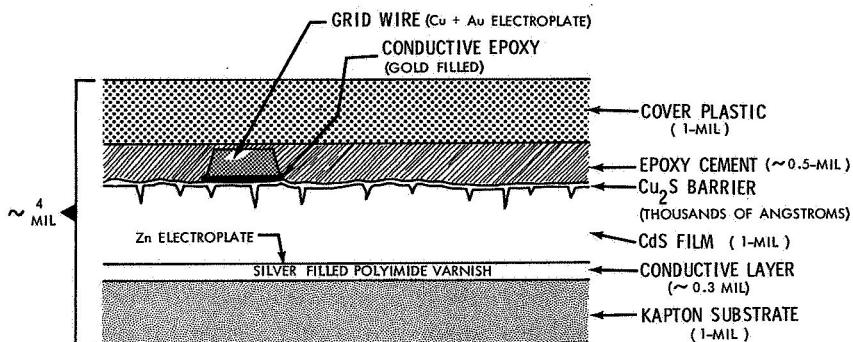


Figure 5-4. CdS thin film solar cell.

and temperature cycling, such as would be encountered on a space-craft, is a serious problem.

Improvements were also made in conversion efficiency; however, substantial further improvements are needed. The average efficiency for present cells (before degradation) is about 3½ percent for the CdS cell as compared to 10½ percent for silicon solar cells. Recent progress has been encouraging, but more effort is required if the potential cost savings benefits are to be realized.

#### Chemical Power Generation

The electrodes of reliable, long-lived, compact fuel cells must be developed in a way that will enable them to fulfill several functions well. A catalyst should activate the reactant so as to minimize the loss of energy at the electrode. The more powerful the catalyst, the lower can be the operating temperature and the less is the energy loss (polarization). The catalyst should be uniformly distributed in, and only in, the active zone of the electrode to avoid causing hot spots and dead spots. Limiting the catalyst to the active zone, near the boundary between the liquid electrolyte and the gaseous reactant, reduces the amount of catalyst needed. The structure of the electrode should make it easier to transport gaseous reactant to the active zone and to remove heat, thus improving the efficiency of the fuel cell.

These and related aspects of fuel cell research were pursued further through contract and grant studies. Work on improved catalysts pointed the way to a new class of alloys that may well surpass the performance of the best presently available cathodic (oxygen) electrocatalysts.

A Ph. D. thesis on the nature of pores in fuel cell electrodes established that it is possible to use only 10 percent or less of the usual quantity of catalyst and, by controlling its distribution carefully, to

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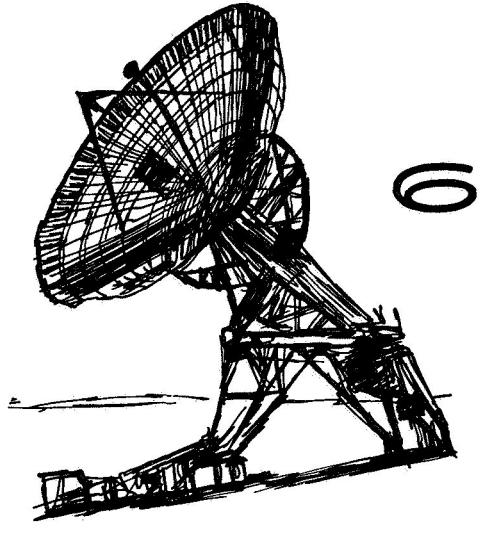
obtain the same performance from the cell. This thesis was developed under a NASA research grant to the University of Pennsylvania. The encouraging results from this academic study are to be followed by an effort to engineer a process of forming thin electrocatalyst layers and simultaneously building thin cells.

In a third study, researchers found that choice of electrode structure, choice of catalyst, electrolyte concentration, and pressures all depend on the way in which a fuel cell is to be used. At low power density, investigators obtain high efficiency in big power plants, suitable for long-term use. At high power density, efficiency is lower but size and weight are also less, so this mode of operation is better for use during brief periods. In the first case, a thicker electrode, a silver cathodic catalyst, a high concentration of electrolyte, and a low pressure difference between electrolyte (liquid) and oxygen (gas) are best. In the second case, a thinner electrode, more dilute electrolyte, and higher pressure difference were found to be better. Also, there was no appreciable difference among platinum, palladium, and silver when cells were operated at high current densities and hence high power densities.

### **Electrical Systems Technology**

Tests verified the feasibility of designing and fabricating power conditioning and control equipment to support unmanned planetary spacecraft wherein capsule sterilization and high impact landing would be necessary.

An experimental power control unit, including controls and circuitry for switching, conditioning, and distributing the several needed regulated voltages, was successfully subjected to a typical sterilization cycle (125° C. for 72 hours). Also this unit underwent free fall drop testing from an altitude of 250 feet (equivalent to 2,500 g's). Subsequent laboratory tests indicate no resulting degradation in power control unit performance.



## TRACKING AND DATA ACQUISITION

The NASA tracking and data acquisition networks continued to support a substantial number of space missions during the period. Support was provided to 69 flight missions, 10 of which were launched during the period. The major NASA missions successfully launched included Surveyor VII, Orbiting Geophysical Observatory (OGO) V, and Apollo 5 and 6.

The Apollo instrumentation ships and aircraft reached operational status during the period, thus completing the Manned Space Flight Network facilities required to support the Apollo lunar landing mission. The network facilities and operating personnel were engaged in mission simulations and preflight checkout for the AS-205 mission, scheduled for the last quarter of 1968.

### Deep Space Network

During the report period, the Deep Space Network supported the final flight in a series of highly successful Surveyor spacecraft. From liftoff (January 7, 1968), the network facilities maintained continuous contact with Surveyor VII, transmitting the data received to the Space Flight Operations Facility (SFOF), the control center for the Deep Space Network. (Fig. 6-1.) At the SFOF, located at JPL, Pasadena, California, the data were processed and displayed in real time, enabling project personnel to make the necessary decisions for mission control. Based on these data, commands were sent via the network stations to the spacecraft, directing the midcourse maneuvers, the soft lunar landing, and the on-board visual imaging cameras.



Figure 6-1. Space Flight Operations Facility.

Guided by commands from the SFOF, Surveyor VII successfully soft-landed on the moon near the crater Tycho on a mission of scientific exploration. The last contact with the spacecraft occurred on February 20, 1968, at which time over 21,000 television pictures had been received by the network stations, including several pictures viewing the earth. The stations also received many hours of data from the Alpha scattering experiment, designed to determine lunar material properties.

Despite completion of the unmanned lunar programs (Lunar Orbiter and Surveyor), the network continued to have a substantial workload, supporting the Pioneer VI, VII, and VIII missions. Originally planned with a useful lifetime of six months, these reliable spacecraft have exceeded all expectations and their lifetimes are now estimated at five years. The increased lifetimes now allow near simultaneous sampling of important phenomena and solar particles in our solar system at widely distributed points. While yielding a true bonus of scientific data, the extended lifetimes saturated the capability of the single 210-foot antenna at Goldstone (the only facility capable of receiving data from the Pioneers at the maximum distances from earth as they proceed in their trajectories around the sun). (Fig. 6-2.) To provide total support to the Pioneers, the 85-foot antennas were im-

proved to increase their capability for receiving data from greater ranges. These improvements have allowed a significant increase in the support provided the Pioneer missions during the report period.

In addition to supporting NASA spacecraft during the report period, two of the Deep Space Network tracking stations at Goldstone, California, were used to successfully track the Asteroid Icarus as it passed within 4 million miles of the earth on June 14. An 85-foot diameter antenna, with a powerful 450-kilowatt transmitter, was used to transmit radio waves to the asteroid and the 210-foot diameter antenna received the radio wave echoes some 42 seconds later. The first signal was detected at 11 p.m. PDT on June 13, and the last signal was received at 4 a.m. PDT on June 16. The asteroid's orbital path made it possible to maintain continuous coverage of Icarus from the Goldstone location. Except for an eight-hour interruption while the 210-foot antenna was supporting the Pioneer spacecraft, the Deep Space Network obtained over 40 hours of data from the asteroid.

The Satellite Network continued to carry a very substantial workload, providing tracking and data acquisition support to some 63 satellites. (Seven of these were launched during this period.)

<i>Mission</i>	<i>Date Launched</i>
GEOS-II	January 11.
OGO-V	March 4.
Solar Explorer XXXVII	March 5.
OVI-13*	April 6.
OVI-14*	April 6.
ESRO-II	May 17.
EGRS-10*	May 18.

\*Other Government agencies' scientific satellites.

One of the highlights of the report period was the support of the second Geodetic Earth Orbiting Satellite (GEOS-II). Launched January 11, 1968, GEOS-II was receiving support from STADAN and the SAO optical network. Also participating in the tracking effort were camera stations of the Coast and Geodetic Survey, the U.S. Air Force, and the U.S. Army Map Service. Additional radio ranging and tracking support was being provided by the Navy Doppler Tracking Network (TRANET). The information obtained by these additional tracking facilities will provide the experimenters and participating Federal agencies with very precise geodetic data.

The launch of the highly successful OGO-V on March 4, 1968, marked the last of the missions requiring support by the mobile tracking and telemetry facility in the Darwin, Australia, locality. Subsequently, the van-mounted 14-foot parabolic antenna and related equipment were being refurbished at Goddard. This mobile facility is

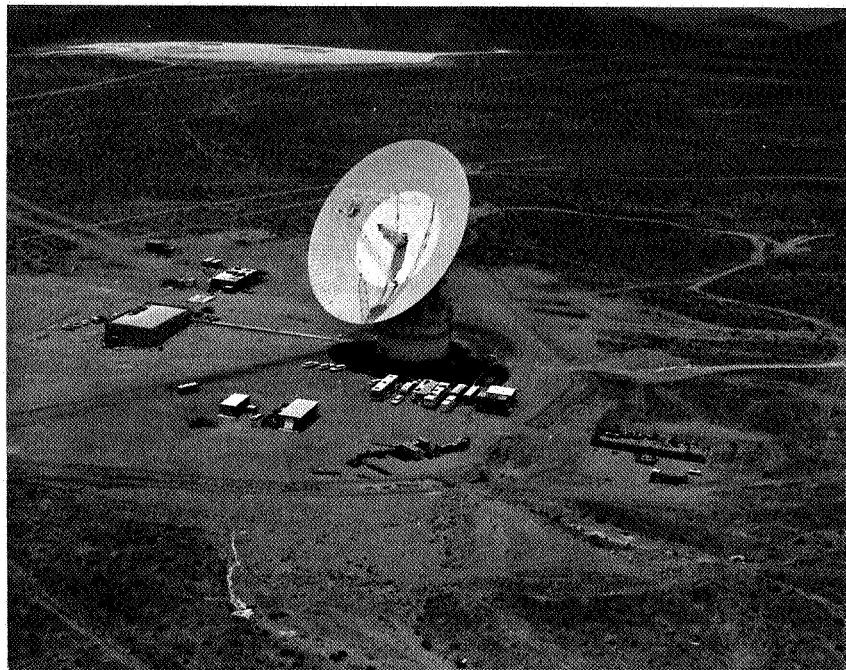


Figure 6-2. The 210-foot antenna at Goldstone.

to be installed aboard a Department of Defense ship for support of the next, and final, OGO mission.

On May 23, 1968, the Satellite Network's support of the world's first passive communications satellite, Echo I, ended when the satellite reentered the atmosphere. The Satellite Network supported Echo I throughout its lifetime, providing the news media with daily predictions indicating where the satellite would pass and when. Easily visible to the unaided eye, Echo I had been viewed by millions of people around the world for nearly eight years.

### Manned Space Flight Network

The Manned Space Flight Network continued to play an active role in supporting NASA's flight missions, despite the delay in manned Apollo missions. Selected network stations provided launch support during the report period to many unmanned missions, including Surveyor and the Orbiting Geophysical Observatory. In addition, the network continued its support of the Titan III-C vehicle development flights and other Department of Defense programs.

As noted in the *18th Semianual Report*, all the land stations required to support the Apollo lunar landing were operational, and the

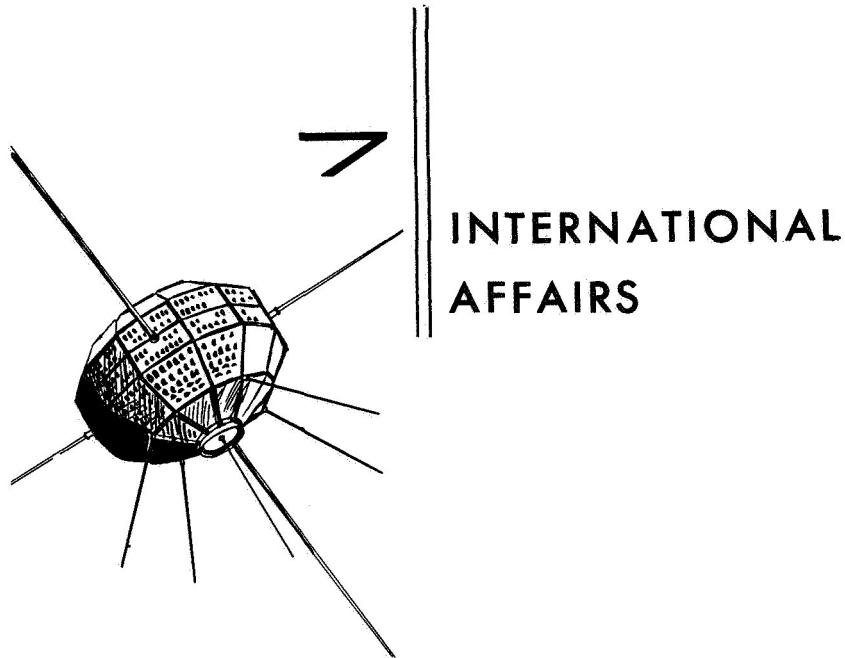
construction and modification of the Apollo ships and aircraft were completed. During this report period, the ships and aircraft became operational, enabling the Manned Space Flight Network to provide full support for the lunar landing. NASA now has no further need for the two Department of Defense tracking ships, the *Rose Knot Victor* and the *Coastal Sentry Quebec*. The NASA tracking equipment was being removed from them and will be used at the network ground stations.

The first flight (Apollo 5) of the Lunar Module (LM) was successfully launched January 22. During this mission, the importance of a reliable ground-based network, staffed by skilled operating personnel, was again illustrated. As has been the case in certain past missions, both manned and unmanned, the capability to transmit precise commands to the spacecraft became the determining factor in assuring mission success. The Apollo 5 mission was headed for failure—premature shutdown of the descent engine—until corrective commands were sent up from the ground stations. Working with data received by the network, flight controllers at the Mission Control Center, Houston, Texas, quickly determined the cause of the shutdown and issued commands to correct the problem. The competence demonstrated by the network in its support of Apollo 5 added to NASA's confidence in its ability to support the lunar landing.

The network performed equally well during its support of Apollo 6, launched April 4. In addition to the land stations, seven of the eight Apollo/Range Instrumentation Aircraft were deployed for mission support: two in the Pacific, two in the Atlantic, one in the Gulf of Mexico, and two available for backup in the Gulf and at Bermuda. The aircraft in the Pacific acquired the spacecraft during terminal reentry and followed it to splashdown.

The network's successful support of the Apollo 5 and 6 missions resulted in large measure from the experience gained from the numerous mission simulations conducted between flight missions. A Test and Training Satellite (TETR, formerly TTS) provided the means of conducting realistic simulation of network and control center operations for Apollo orbital missions.

The first such satellite, TETR-1, which was launched during the previous reporting period (see *18th Semiannual Report*), reentered the earth's atmosphere on April 26. During the satellite's lifetime over 600 orbital passes were supported by the network, including the Apollo ships, in training and checkout exercises. In addition, the spacecraft was used in network mission simulations involving real-time orbit computation and prediction, dispersal of acquisition messages, and checkout of the Unified S-band system. A second Test and Training Satellite is scheduled for launch in the last half of 1968.



NASA extended its international cooperative projects and support programs by adding a number of new activities. These activities increased the scope and depth of this nation's international involvement in space works.

#### **Cooperative Projects**

The launching of the ESRO II spacecraft, a satellite built by the European Space Research Organization, highlighted the Agency's cooperation with research institutions and scientists in foreign countries, and with international organizations. Other significant achievements included the launching of British, French, and Dutch experiments on the NASA OGO V Satellite; an agreement on the first cooperation projects with Mexico and Switzerland; selection of the first foreign experiment for the Apollo Lunar Surface Experiment Package (ALSEP); selection of additional experiments with samples of the lunar surface to be returned in the Apollo Program, bringing the total to 31 foreign investigators from seven countries; and new cooperative research in aeronautics. In all, ten new agreements were completed with Brazil, France, Germany, Mexico, Norway, Spain and Switzerland.

#### **Brazil**

The Brazilian National Commission on Space Activities (CNAE) and NASA concluded an agreement on June 26 for a cooperative

sounding rocket project designed to measure meteoroid flux in the upper atmosphere.

The Barreiro do Inferno Range at Natal continued to be active with eleven cooperative US/Brazilian launchings during the reporting period. Pursuant to a February 9 agreement with Brazil, the first of a series of three Black Brant IV rockets was launched in June to sample radiation dose rates in the South Atlantic Anomaly Region of the Van Allen belt. The launching of three Nike-Cajun rockets in March from Natal concluded the study begun in 1965 of winds, temperature, and density changes in the equatorial mesosphere at different periods of the year. Seven cooperative launchings were also made under the Experimental Meteorological Sounding Rocket Network (EXAMETNET) program.

#### Canada

A developmental version of the very low frequency experiment, designed and fabricated by the Canadians for the ISIS-A spacecraft, was successfully launched from NASA's Wallops Station on May 7 on a Canadian manufactured Black Brant IV rocket. (Fig. 7-1.) This launching was conducted as part of the International Satellite

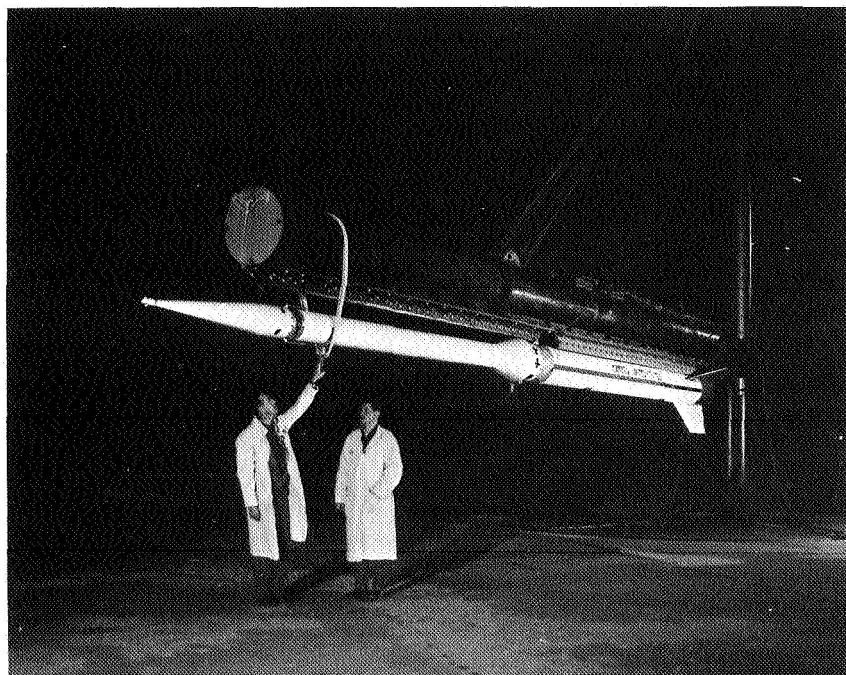


Figure 7-1. Canadian manufactured Black Brant IV rocket launched from Wallops Station on May 7, 1968.

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for Ionospheric Studies program (ISIS) undertaken to conduct comprehensive studies of the ionosphere from the approaching minimum through the next maximum of the present solar cycle.

In the aeronautics area, NASA and the Canadian Defense Research Board undertook the joint funding of a wind tunnel research project to study the "augmentor wing" concept, a promising new design concept for STOL aircraft.

### **European Space Research Organization (ESRO)**

The ESRO II satellite, containing seven experiments from three countries, was successfully launched from the Western Test Range by a NASA Scout launch vehicle on May 16, 1968. (Fig. 7-2.) ESRO II is a solar astronomy and cosmic ray satellite, designed to conduct radiation and proton experiments. This is a backup spacecraft, replacing the one lost when the third stage of the Scout vehicle malfunctioned during the unsuccessful launching attempt of May 1967. Meanwhile, preparations were well advanced and on schedule for the launching by NASA of the ESRO I and the Highly Eccentric Orbit Satellite (HEOS) spacecraft scheduled for late in 1968. The HEOS launching by a Thor Delta vehicle is to be NASA's first reimbursable launching of a foreign spacecraft.

### **France**

In March, NASA and the French Space Commission (CNES) agreed to cooperate in conducting a regional geodetic survey of the Mediterranean basin, utilizing space techniques. In this project, NASA will command a predetermined number of GEOS II satellite flashes over the Mediterranean area, which three French ground stations will observe by laser telemetry and photographic techniques. The data obtained will be forwarded to NASA's Goddard Space Flight Center.

NASA and the French National Office of Aerospace Research (ONERA) agreed (May 13) to conduct a cooperative wind tunnel research project to test tilt rotors for V/STOL aircraft. Wind tunnels in the United States and France will be used to carry out the project.

### **Germany**

The results of the cooperative NASA/German radiation-belt research satellite's sounding rocket phase were analyzed; they showed that the proposed satellite's instrumentation was properly designed and would perform successfully. Subsequently, the agencies involved decided to proceed with preparation of the satellite for a launching late in 1969.

NASA and the German Federal Ministry for Scientific Research (BMwF) agreed on March 8 to continue their highly successful coop-

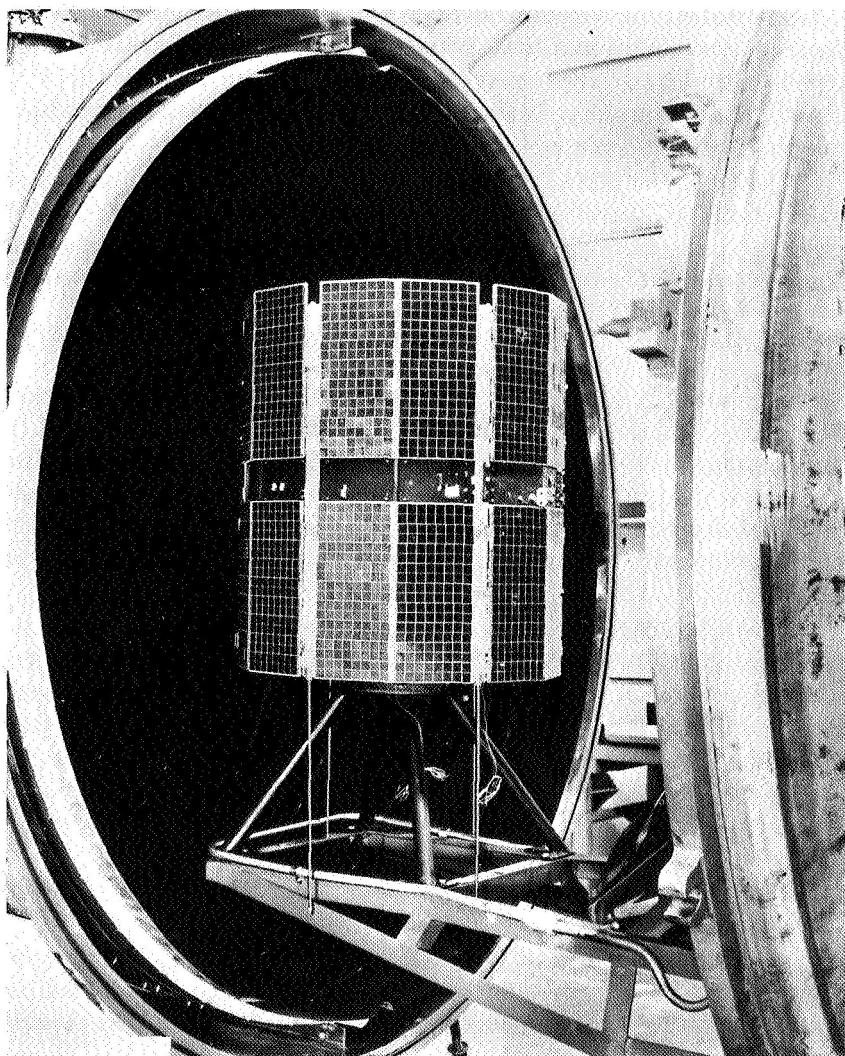


Figure 7-2. The ESRO II satellite, launched May 16, 1968.

eration in using the artificial barium ion cloud technique. Electric fields in the equatorial electrojet were investigated by barium ejection from four Nike-Apache rockets. These rockets were launched from the Thumba Equatorial Rocket Launching Station (TERLS) in southern India in March. The BMwF made a separate bilateral agreement with the Indian National Committee for Space Research (INCOSPAR) to carry out the launchings of the NASA-supplied rockets. Data from these experiments are made available to all three parties.

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Under an earlier cooperative NASA-BMwF agreement, four Nike-Apaches were also launched from Kiruna, Sweden, in March and April. Three launchings completed a series begun in April 1967 to investigate the physics of comets, the interplanetary medium, and the earth's magnetosphere by observing artificial ion clouds.

NASA and the BMwF agreed in June to a cooperative project to study stability control and handling qualities of the Dornier DO-31 aircraft during landing, transition, and descent phases of flight on an Ames Research Center flight simulator. The DO-31 is unique as an advanced jet V/STOL transport aircraft.

### **India**

The joint NASA-Indian Instruction Television Study Group, formed in October 1967, considered a special demonstration project in conjunction with future NASA communications experiments. The purpose of the project would be to determine the effectiveness of satellite-broadcast instructional television programs in increasing agricultural productivity and introducing family planning concepts to some Indian villages. A report was being prepared.

Meanwhile, NASA and the Indian National Committee for Space Research (INCOSPAR) continued cooperation under earlier understandings. Three NASA-supplied Nike-Apache sounding rockets were launched in February and April from the Thumba Equatorial Rocket Launching Station (TERLS). The February launching was designed to measure neutral atmospheric winds above 85 kilometers and to measure electron densities in the upper atmosphere. The two April launchings were designed to study stellar X-ray sources. Payloads for the latter two rockets were prepared under a separate Indian-Japanese bilateral understanding.

Two other launchings of Boosted Arcas I rockets were made from TERLS in March to investigate the electron density distribution in the D region of the ionosphere by means of radio propagation experiments. These experiments were conducted by NASA's Goddard Space Flight Center.

### **Italy**

NASA and the Italian Space Commission are proceeding with the development of the San Marco C spacecraft, which will carry a more advanced version of the Italian San Marco B air density experiment and two mass spectrometry experiments from Goddard Space Flight Center. San Marco C is intended to investigate and define the equatorial neutral atmosphere in terms of density, composition, and temperature behavior and variations resulting from solar and geomagnetic activity. The satellite is to be launched from the San Marco platform

off the coast of Kenya by an Italian launching crew in late 1969 or early 1970.

#### **Mexico**

In January, NASA and the Mexican Commission for Outer Space (CNEE) reached an agreement concerning a new cooperative meteorological research project. Through this agreement, NASA is loaning an Automatic Picture Transmission (APT) set to CNEE; in turn, CNEE is establishing and documenting a "systems" approach to the practical use of the data in Mexico by various Mexican government agencies. The results of the Mexican experience will be of great interest to other, particularly developing, countries throughout the world.

#### **Norway**

NASA and the Norwegian Council for Scientific and Industrial Research (NTNF) agreed to conduct a series of five sounding rocket launchings from the Norwegian range at Andoya during the third quarter of 1968. The purpose of this project is to study the dynamics of the auroral ionosphere by observing the electric and magnetic field and the charged particle environment during various stages of auroral activity. The Norwegians are to provide two of the payloads and both the launching and the tracking and data acquisition services.

#### **Spain.**

In January and February Spain launched six small meteorological sounding rockets at its Arenosillo Range on the southwest coast. These were the last of a series of sixteen launchings agreed to in January 1966 between NASA and the Spanish Space Commission (CONIE); they were designed to provide information on the dynamics of atmospheric circulation.

In a new Memorandum of Understanding signed June 26, NASA and CONIE agreed to extend this project. This continued cooperative effort calls for the launching of a series of 24 small meteorological rockets over a period of 2 years (12 per year).

#### **Switzerland**

NASA and the Swiss Committee for Space Research agreed to cooperate in a project for a high altitude balloon experiment for stellar and near ultraviolet observations. The balloon payload, developed at the Observatory of Geneva, is to be launched in late 1968. NASA will provide the high altitude balloon. The National Center for Atmospheric Research, through its agreement with NASA, is to conduct the launching at its Palestine, Texas facility.

Berne University has supplied the first foreign experiment to be selected for the Apollo Lunar Surface Experiments Package (AL-

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SEP). The experiment consists of an aluminum foil screen to be deployed on the moon to trap elements of the solar wind and then returned to earth by the astronauts. Although experiments for the ALSEP project were selected in 1966, this late proposal was so significant that it was subsequently incorporated into the experiments package.

### **Cooperative Earth Resources Research Project**

More than twenty-five Brazilian and Mexican scientists met February 7 at the NASA Manned Spacecraft Center to begin the first phase of a pioneer cooperative international effort to develop techniques and systems for obtaining and using earth resources data from aircraft. The initial phase of the 3-year project calls for training personnel in the reduction and analysis of remotely sensed data.

### **Foreign Experiments Flown on OGO-V**

The fifth Orbiting Geophysical Observatory (OGO-V), launched from Cape Kennedy on March 4, carried more foreign experiments than did any other NASA satellite. Of the twenty-four experiments on board, four were contributed by foreign groups: the University of Southampton, England; the University College, London; the Cosmic Ray Working Group in The Netherlands; and the University of Paris. These experiments were concerned respectively with primary cosmic rays, electron temperature and density, flux and energy of cosmic-ray electrons, and the temperature and density of hydrogen in the geo-corona. The Netherlands' experiment is the first from that country to be flown on a NASA satellite.

### **Inter-American Experimental Meteorological Rocket Network (EXAMETNET)**

The EXAMETNET makes use of launching stations in a chain running longitudinally through the western hemisphere. The network is designed to study the structure and behavior of the atmosphere in the southern hemisphere. It also seeks to identify the causes of the differences and similarities of the structure and circulation of the atmosphere in the northern and southern hemispheres. It continued active during the reporting period. Coordinated launchings were made from Argentina, Brazil, and Wallops Island. Argentina launched twelve Boosted Dart and Arcas I rockets, and Brazil launched seven. There were twenty-five launchings from Wallops Island.

### **Lunar Surface Sample Program**

As of the end of June, thirty-one foreign investigators from seven countries and eighteen institutions had been selected to perform one or more experiments on lunar surface material to be returned by

Apollo lunar missions. The countries represented include Belgium, Canada, Finland, Germany, Japan, Switzerland, and the United Kingdom. Among the thirty-eight approved experiments are investigations in mineralogy and petrology, chemical and isotope analysis, physical properties, and biochemical and organic analysis.

### **United Nations**

The General Counsel of NASA served as Alternate U.S. Representative to the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space. The subcommittee met in Geneva from June 4 to June 28, 1968.

### **Operations Support**

Foreign support for NASA activities continued and was amplified. On May 3, the United States and the United Kingdom concluded an agreement to establish and operate a tracking station on Grand Bahama Island to support Apollo. This station plays an important role in obtaining early tracking and telemetry information on the spacecraft following its launch from Cape Kennedy.

In addition, the Bermuda Tracking Station agreement with the United Kingdom was broadened to include support of non-experimental spaceflights of a peaceful and scientific character.

NASA arranged with Ethiopia, Mauritius, Brazil and Chad for the temporary location of observation equipment within their territories in support of the National Geodetic Satellite Program (NGSP). At this time twenty-two foreign countries have approved such observation sites.

Australia, Brazil, and the Netherlands have approved the staging of Apollo/Range Instrumentation Aircraft (A/RIA) on airfields under their jurisdiction, in support of Project Apollo. These specially instrumented aircraft will receive and record telemetry and serve as voice communications relay during injection and earth re-entry phases of manned lunar missions.

Canada permitted use of certain of its facilities for an instrumented Convair 990 which conducted arctic flights during January and February to observe auroral phenomena.

### **Personnel Exchanges, Education and Training**

During the first half of 1968, over 3,700 foreign nationals from 84 countries visited NASA facilities for scientific and technical discussions or general orientation.

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Under the NASA International University Fellowship Program, 37 students either entered the program or continued their studies. Twelve countries and 15 universities participated in this program during the period. They were supported by their national space research sponsors or by the European Space Research Organization (ESRO). This program is administered for NASA by the National Academy of Sciences.

One hundred and seventeen postdoctoral and senior postdoctoral associates from 23 countries carried on research at NASA centers, including the Jet Propulsion Laboratory. This program is also administered by the National Academy of Sciences and is open to U.S. nationals.

Thirty-seven scientists, engineers, and technicians representing Brazil, Germany, and Mexico—here at their own expense—received training in space technology at the Goddard Space Flight Center and the Manned Spacecraft Center in connection with cooperative projects.



## UNIVERSITY PROGRAMS

The principal goal of the NASA University Program has been to bring universities into full participation in the aerospace program as members of the government-industry-university team so that they will contribute to NASA's objectives, and so that, in turn, their research and education capability will be strengthened.

The university program has two separately identifiable yet closely interrelated parts—project-oriented research grants and contracts supported by program offices and centers, and Sustaining University grants for special training, research, and facilities.

### Sustaining University Program

As in the previous period (*18th Semiannual Report*, p. 143), the Sustaining University Program was modified to meet the changing conditions of the space program. Programs aimed only at expansion and building new capabilities for purely scientific and technical research were cut back or phased out, and to the maximum extent possible, discipline-oriented research was being transferred to NASA program offices and centers responsible for the particular areas of research.

Also, as reported previously, funding of new university facilities was terminated, multidisciplinary research was reduced, and regular predoctoral training grants to universities were discontinued.

The multidisciplinary research, engineering systems design, management and administration research, and special training elements of the Sustaining University Program received continued emphasis during this period.

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### **Multidisciplinary Research**

This program continued to support broad long range research involving more than one academic discipline and requiring greater participation by the university administration than project research.

Designed to bring the universities into closer partnership with NASA in advancing national aerospace science and technological resources, the program enhances the fiscal and academic strength of the university and also permits greater participation in space research on a broad geographic basis. In this period, although budget restrictions necessitated a reduction in support to almost all multidisciplinary research grants, support was provided to 45 universities.

### **Engineering Systems Design**

This pilot program calls for graduate students to work as part of a multidisciplinary team on systems engineering problems modeled closely after those being dealt with by government and industry. The first group of 23 trainees at five universities—Purdue, Cornell, Stanford, Kansas, and Georgia Tech—started training in September 1967, and spent the school year (1967–1968) in completing course work and preparing for qualifying exams. Students and faculty advisors investigated and analyzed possible space-related projects for the team project. Some of the teams and faculty members have visited NASA centers.

A second grant of five traineeships each, to each of the five participating schools, was made for students to start in September 1968.

### **Administration and Management Research**

Significant progress was made in developing and expanding this program to train people in the management and administration of technological and scientific programs. In addition to the graduate training programs in public administration and management at the University of Pittsburgh and the University of Southern California, a new training program was established at Syracuse University. Each of these three training programs is also supported by a NASA-oriented research program which will produce new ideas, concepts, and procedures for the Agency. Special research programs in management and administration were also begun at Northwestern University and the University of New Mexico. A general review of the scope and direction of the program, held at Syracuse University in June, was attended by representatives of all the participating universities.

### **Special Training**

Special training includes the Summer Faculty Fellowship Program, Summer Institutes for talented undergraduates, a post-M.D. effort

to provide advanced training in support of the manned space program, and a few predoctoral training grants in specific disciplines related to the national space program.

The Summer Faculty Fellowship Program in Research, established in 1964, seeks to expand the professional knowledge of engineering and science faculty, to stimulate the exchange of ideas between them and NASA, and to enrich the research and teaching activities at participant schools. During this period, 13 universities and 9 field centers cooperated by offering 10 weeks of research and study opportunities to about 250 faculty members.

A Summer Faculty Fellowship Program in Engineering Systems Design was started during 1966 to enable young faculty members to develop the background and competence to organize multidisciplinary engineering systems design courses at their home institutions. During the summer of 1968, about sixty faculty members were scheduled to participate in three programs conducted by Stanford University in cooperation with the Ames Research Center; the University of Houston in cooperation with Rice University and the Manned Spacecraft Center; and Old Dominion University in cooperation with the College of William and Mary and the Langley Research Center.

Awards for 1968 summer institutes for outstanding undergraduates were made to Columbia University, the University of California at Los Angeles, University of California at Santa Barbara, and the University of Maryland. The purpose of these programs is to give selected upper division undergraduates knowledge of the substantive problems of space science and engineering and administration and management. About 125 senior undergraduates are to receive six weeks of specialized training in space science and technology in these institutes.

NASA continued to support training in aerospace medicine at Harvard University and Ohio State University, with the latter receiving a grant during this period for continuation of the program.

Early in 1968, a predoctoral training grant was awarded to Stanford University specifically for training five students in laser technology.

*Resident Research Associateship Program.*—This program, administered for NASA by the National Research Council, the National Academy of Sciences, and the National Academy of Engineering, permits postdoctoral investigators to carry on advanced research in space-related science or technology in NASA field centers. The 171 scientists

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conducting research under this program were distributed among NASA centers as follows:

<i>Center</i>	<i>Participants</i>
Goddard Space Flight Center-----	84
Institute for Space Studies, N.Y-----	19
Greenbelt, Maryland-----	65
	<hr/>
Ames Research Center-----	44
Marshall Space Flight Center-----	10
Eangley Research Center-----	14
Manned Spacecraft Center-----	4
Jet Propulsion Laboratory-----	13
Electronics Research Center-----	2
	<hr/>
Total -----	171

### **Research Facilities**

During this period, graduate research facilities were dedicated at Wisconsin, Denver, and M.I.T. The Space Sciences Center at M.I.T., dedicated on April 25 by the Administrator, was the 28th structure completed under the Research Facilities Program. These buildings now provide slightly over a million gross square feet of space, and accommodate about 2,900 scientists, engineers, and other researchers.

On March 1, the award of a facilities grant to the NAS-NRC was announced. This, the 37th such grant to be awarded, is for construction of facilities which will become the Lunar Science Institute, a national enterprise which will accommodate researchers in various aspects of lunar sample analysis from institutions throughout the United States.

Table 8-1 summarizes the status of the nine active grants.

### **Unsolicited Proposals**

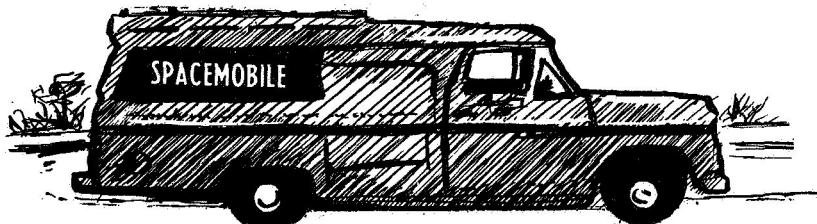
The Office of University Affairs continued preparation and distribution of a monthly inventory of university or industrial proposals under review, categorized by age and by responsible office. This service has improved the NASA response time and reduced the inventory of proposals still under review. At the beginning of this period 1,592 proposals were on hand. During the period, 1,474 proposals were received, 1,249 were declined, 885 were funded, and as of the closing date, 932 were still under review.

Table 8-1. Research facilities in progress

Fiscal year awarded	Institution	Topic	Area (1,000 SF)	Percent com- plete	Cost (\$1,000)
1965.....	Case Western Reserve.....	Space Engineering.....	69	75	\$2,226
Do.....	Rochester.....	Space Sciences.....	35	75	1,000
Do.....	Florida.....	Space Sciences.....	53	99	1,190
Do.....	Minnesota.....	Space Sciences.....	70	99	2,500
Do.....	Stanford.....	Space Engineering.....	65	70	2,080
			292	-----	8,996
1966.....	Wisconsin.....	Space Science & Engineering.....	58	75	1,694
Do.....	Washington.....	Aerospace Research.....	40	25	1,500
Do.....	Kansas.....	Space Technology.....	56	(1)	1,800
			154	-----	4,994
1968.....	National Academy of Sciences/National Research Council.	Seitz/Lunar Science Institute.	17	(1)	580
			17	-----	580
Total.....			463	-----	14,570

<sup>1</sup> Design.

# INFORMATIONAL AND EDUCATIONAL PROGRAMS



NASA cooperated with industry, academic institutions, private organizations, and other governmental agencies at all levels to broaden the base of its informational and educational programs and at the same time to reduce costs. Brief descriptions of some joint projects follow.

## Educational Programs and Services

Based on the Nation's aeronautics and space activities, the Agency has devised a series of resource guides for education in the aerospace age to serve secondary school teachers and students. First published was *Industrial Arts Resource Units* prepared by industrial arts teachers from Georgia, Florida, Puerto Rico, and the Virgin Islands under the direction of teacher-educators from Western Michigan University and the University of South Florida. Resource guides in biology, physics, chemistry, mathematics, and the physical sciences were in process.

In addition, NASA supplied consultants, publications, audiovisual materials, and lecturers to 375 workshops and courses for over 13,822 teachers; it also answered technical questions and provided information on careers for more than 1,500 students and teachers.

In its Youth Science Congress program, NASA recognized 222 high school students for outstanding science projects. At 12 regional congresses, the students presented their research findings to other students, scientists, and engineers for comment and criticism, and ob-

served scientists at work in space-related projects. The congresses were held at NASA centers in Massachusetts, Maryland, Virginia, Alabama, Florida, Ohio, Texas, and California and at aerospace industrial complexes in Missouri, Colorado, Minnesota, and California.

The Agency also presented certificates of merit to six of the 414 high school students who entered exhibits or displayed their projects in aeronautics and space at the International Science Fair in Detroit. Each winner, accompanied by a teacher of his choice, was awarded a visit to one of NASA's field installations. Nine more students were selected for honorable mention and received letters of commendation. The contestants for the Detroit fair were selected from over 225 local and regional fairs. NASA awarded certificates for 192 state and regional programs, and provided judges whenever possible.

#### **Spacemobiles**

NASA's traveling space science lecture-demonstration units (spacemobiles) made 7,448 presentations before school children, and educational and civic groups. In addition to this audience of 1,846,218, an estimated 4,229,705 persons were reached through 31 radio and television programs. Abroad, spacemobiles in Brazil, Colombia, the Philippines, the Netherlands, and Morocco were manned by local lecturers trained by NASA spacemobile specialists.

#### **Educational Publications and Films**

NASA released 15 new publications and a new motion picture which are described in detail in appendix M.

#### **Educational TV and Radio**

The *Challenge of Space* series—ten half-hour films on a wide range of topics covering aerospace research and development—was televised by stations throughout the United States and in the Philippines. Seen by an estimated 65 million people, these films were added to NASA's regular listing of motion pictures available for television. Also, *Apollo Digest*, short films on various aspects of the Apollo manned space flight program, will be released in the near future. Produced jointly by NASA Headquarters, Kennedy Space Center, Marshall Space Flight Center, and the Manned Spacecraft Center, this series of 29 five-to-ten-minute films will be made available to networks, as well as to individual TV producers. In addition, three half-hour television films on the space sciences, technology utilization, and electronics research were being produced.

Besides providing program material to radio and television stations, NASA furnished guidance to individual producers and helped them with space-related productions, and also supplied information and other visual materials to the industry.

### Scientific and Technical Information

In this period NASA made substantial progress in its RECON and SCAN computerized information storage and retrieval systems.

#### The RECON System

After extensive tests of remote-console information retrieval networks, the Agency awarded a contract for the computer software needed to operate an information retrieval system of this type. The system called RECON—to be developed by the contractor—will consist of numerous remote consoles installed at NASA Headquarters and at its field centers. Initial operation of the RECON system in Washington was scheduled for late this year, with the expansion of the service to the field installations to come later.

The remote consoles, linked to a central computer at NASA's Scientific and Technical Information Facility in College Park, Md., will supply real-time, on-line access to the Agency's worldwide collection of scientific and technical aerospace documents.

A user of the RECON system will need no special skills nor training. He simply sits at a small console and uses a typewriter keyboard to ask the computer what to do and then follows through with his questions for information. The computer's answers, in simple English, are displayed on a TV-like screen above the console. When the user sees a description of a document he wants, he presses a button to notify his local library of his request.

#### The SCAN System

At the same time, NASA carried out a major expansion of its SCAN system for selective dissemination of information. (*15th Semiannual Report*, p. 139.) The SCAN system—Selected Current Aerospace Notices—is a low-cost program using computer search techniques and standardized topic profiles to announce to scientists and engineers the latest available information in their fields of special interest.

From the few organizations which helped develop it, the SCAN service now extends to hundreds of organizations including Navy and Air Force installations as well as NASA research and development contractors. Also, special arrangements were made with the American Institute of Aeronautics and Astronautics to make this system available to its member organizations on a trial basis.

#### Technical Publications

A number of the Agency's most current special publications are listed in appendix N.

### **Technology Utilization**

The NASA Technology Utilization program made steady progress in helping bring about nonaerospace applications of the knowledge derived from aerospace research and development. The Agency stressed increasing public awareness of the potential benefits from using the information made available through technology utilization, and concentrated on improving systems for acquiring, identifying, and documenting the technical information obtained from NASA-sponsored technology.

NASA received an increasing number of requests for information on the innovations, inventions, and discoveries announced in its *Tech Briefs* and described in various compilations. In this period, 21 compilations and descriptions of 355 state-of-the-art advances were published and distributed.

Two of the Agency's older Regional Dissemination Centers at Indiana University and the University of Pittsburgh—which have helped to bridge the technical information gap between Government, industry, and academic institutions—have decided to continue as self-supporting centers after NASA's initial financial support is discontinued in the near future. Two other centers previously supported by NASA—at Wayne State University (Detroit) and Midwest Research Institute (Kansas City)—continued aerospace technology dissemination and transfer activities on their own.

An important step in the field coordination of NASA and Department of Commerce technology transfer programs occurred when the director of the regional dissemination center at the University of New Mexico was designated as responsible for the Commerce Department's Office of State Technical Services (STS) program in the state. Also, STS offices in Texas, Arizona, and Nevada became paid members of Technology Applications Centers in those states.

### **Interagency Cooperation**

In cooperative projects with other Federal agencies—designed to effect economies and prevent duplicate dissemination of technical information to private business—NASA continued to help the Atomic Energy Commission issue publications on new technology developed in AEC's laboratories. Among these were the 32 *Tech Briefs*, six compilations, and seven handbooks released by the end of June. Also, the Agency co-sponsored conferences with the Small Business Administration (SBA) and assisted the SBA in its *Tech Aids* publications featuring information derived from NASA programs. Three *Tech Aids* were published and distributed to small businesses throughout the Nation. A cooperative program with the Bureau of Reclamation (De-

partment of the Interior), found NASA helping to pinpoint aerospace technology which might be applied by seven of the Bureau's research groups to their weather modification projects.

In addition, the Agency, the AEC, and the Department of Transportation were considering possible applications of the technology from aerospace and atomic energy programs to the safety inspection of bridges. (This joint investigation was prompted by the collapse of a suspension bridge between West Virginia and Ohio in December 1967 resulting in the deaths of over 32 people.) Several innovations from the research and development of AEC and NASA were identified as possibly applicable to solving bridge inspection problems and a list of these innovations was forwarded to the Department of Transportation for studies of their feasibility.

NASA was also asked to take the chairmanship of a newly appointed task group on technology utilization of the Federal Council for Science and Technology. One of the responsibilities of this interagency group of the Council's Committee on Scientific and Technical Information will be to recommend policies and programs leading to the improved coordination of technology transfer between Federal agencies and nongovernmental organizations.

#### **Conferences**

NASA joined several other Government agencies in sponsoring public conferences on technology utilization. Conferences at Chicago, Ill.; Seattle, Wash.; and at the University of Miami (Oxford, Ohio) were held with assistance from the Small Business Administration. Also participating were the Science Information Exchange of the Smithsonian Institution, the National Referral Center for Science and Technology of the Library of Congress, the Atomic Energy Commission, and the Office of State Technical Services, Department of Commerce. The conferences were planned to illustrate the usefulness of aerospace technology generated by industry, and to describe how businessmen might gain ready access to scientific and technical information from the research and development of the Federal Government.

A 3-day conference at Langley Research Center was attended by New Technology representatives from 50 NASA prime contractors and Technology Utilization representatives from Agency headquarters and field installations. The conference dealt primarily with improving the reporting of new technology by NASA contractors to meet the contractual requirements spelled out by NASA's New Technology Clause.

#### **COSMIC**

The University of Georgia's Computer Software Management and Information Center (COSMIC) continued to gain widespread ac-

ceptance from industry and educational institutions as a marketing outlet for NASA-developed computer programs. Its sales income increased substantially over that of the previous 6 months, indicating that the Center could become self-supporting, as required by NASA, in the next 2 years.

The Department of Defense and the Atomic Energy Commission plan later in 1968 to begin using COSMIC as a central clearinghouse for computer programs resulting from their research and development. Also, NASA and the Defense Department will soon execute an inter-agency agreement to provide for the Department's active participation in this joint venture.

#### **Oklahoma State University Pilot Project**

A NASA pilot project at Oklahoma State University to test the usefulness of educational monographs prepared from the Agency's research and development reports was producing encouraging results. (*18th Semiannual Report*, p. 152.) Over 230 professors at 102 universities in 39 states were sent these monographs for review or for use in their classrooms. Those who used them in the classroom evaluated them favorably. Since this was an experimental program, the Agency's support should be withdrawn when others are ready to assume responsibility for the developmental phase of the project.

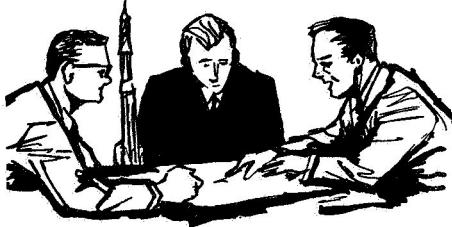
#### **Historical Program**

NASA's Historical Advisory Committee (app. E), meeting at the Manned Spacecraft Center on January 22-23, carried out its annual review and made recommendations for the historical program. The report of the Committee was submitted to the Administrator of the National Aeronautics and Space Administration in July. As in the past, its members recommended that historians taking part in the NASA program continue to be granted unlimited access to documents and freedom to interview people while preparing their histories, and that they remain "unfettered in drawing their conclusions."

Among the major histories being written were accounts of the Gemini and Ranger projects. In addition, steps were taken to begin preparing a history of Project Apollo. Field installations primarily responsible for this program—Kennedy Space Center, Marshall Space Flight Center, and the Manned Spacecraft Center—were assigned principal roles in preparing preliminary monographs. Other NASA Centers will also prepare histories of unmanned spacecraft missions and of aeronautics.

Another seminar on "Space, History, and Social Science" was planned to be held during the summer of 1968 for graduate students in history.

# 10 || PERSONNEL, MANAGEMENT, PROCUREMENT, AND SUPPORT FUNCTIONS



During this period, NASA was confronted with urgent need to make maximum effective use of all its resources in order to maintain its on-going programs, while providing support for the research efforts geared to the extension of the space missions. Personnel training was encouraged; inventions and contributions were recognized; organizational, managerial, and financial management improvements were emphasized; and all procurement actions received careful scrutiny. Additionally, the Agency continued to work with other government agencies and offices where matters of mutual interest were involved.

## Personnel

With its personnel staff remaining fairly stable, NASA concentrated its efforts on upgrading the capabilities of its employees, on assuring equal opportunity for all people regardless of race or sex, on recognizing organized groups of employees, and on making the most effective use of its manpower.

## Employee-Management Cooperation

NASA continued to provide substantial support to the government-wide program for Employee-Management Cooperation in the Federal service (Executive Order 10988). Specifically, the Agency formally recognized three American Federation of Government Employees (AFL-CIO) lodges: Lodge 2498, at the Kennedy Space Center; Lodge 2755, at the Langley Research Center; and Lodge 2841, at the Ames Research Center. It also gave informal recognition to Lodge 2842, American Federation of Government Employees (AFL-CIO) at the Headquarters installation, and to Local 1575, National Federation of Federal Employees (Independent) at the Kennedy Space Center.

**Training Activities**

NASA selected a contractor (under competitive bid procedures and small business criteria) to develop an agency-wide course for first-line supervisors. The Civil Service Commission provided advisory and consulting services. The course will be pilot tested in the last half of 1968. In the future, all NASA first-line supervisors will be required to attend this course or a similar one that meets the same standards and criteria.

NASA continued to provide seminars on an agency-wide basis for specialized training of program and project teams, and for promoting management improvement and uniform treatment of NASA policy where required. During the period, courses in "Procurement Management," "Contract Administration," "Contract Cost Management," "Profit & Fee Negotiation," "Application of Nomographics to Incentive Contracting," "Contractor Performance Evaluation," and "Certification of Cost & Pricing Data" were conducted for NASA employees.

Twelve NASA employees were selected for the 1968-1969 national competitive fellowship award programs as follows: MIT-Sloan—2; Stanford-Sloan—3; National Institute of Public Affairs—3; Princeton-Woodrow Wilson—1; Industrial College of the Armed Forces—2; and the Hugh L. Dryden Memorial Fellowship—1.

NASA installations kept up their cyclic programs such as graduate education; cooperative education; apprentice, science, and engineering lectures; and a wide variety of management and skills training.

**Equal Employment Opportunity**

Equal Employment staff personnel from Headquarters and from Goddard Space Flight Center, visited Bowie State College, a predominantly Negro college located near Greenbelt, Maryland, to determine if Goddard could assist the school in any way. Subsequently, Goddard officials and Bowie State faculty began working together to explore the problem of the school's need for a modern science department; they were also considering other areas of mutual interest and benefit.

**Status of Women**

The NASA Langley Research Center continued to upgrade the skills of all professional employees through numerous training programs designed to improve technical competence and enhance opportunities for future growth. The most significant of these programs is Langley's Graduate Study Program arrangement with the College of William and Mary, with Old Dominion College, with the University of Virginia, and with the Virginia Polytechnic Institute. Under this ar-

angement all requirements for advanced degrees can be met through part-time study.

At period's end, five women employees were working toward a MS Degree in Physics and Mathematics. NASA management considers this availability of part-time graduate study, without a residency requirement, as particularly helpful in attracting qualified women to fill professional positions. It also furthers the objectives of the Federal Women's Program.

#### **Manpower Research and Utilization**

In January, 1968, NASA Headquarters established a separate Manpower Analysis and Plans Branch reporting to the Agency's Director of Personnel. The responsibilities of this Branch include the operation of the automated Personnel Management Information System (PMIS). The Branch thus becomes the focal point for developing and analyzing agency-wide manpower utilization information.

#### **Key Executive Personnel Changes**

Nineteen key executive personnel changes occurred during this reporting period. Seven individuals were appointed to key positions, eight were reassigned, and four left the Agency.

*Appointments.*—On January 20, Bob P. Helgeson was appointed as Director of Safety, NASA. He came to the Agency from the Atomic Energy Commission, where he has served as Deputy Manager of the Richland Operations Office, Richland, Washington.

Charles E. Weakley (Vice Admiral, Retired) was appointed (on February 1) as Assistant Administrator for Management Development, in the Office of the Administrator. Admiral Weakley retired from the Navy in November 1967.

On March 1, Clare F. Farley (Colonel, U.S. Army, Retired) was appointed as Executive Officer, also in the Office of the Administrator, following his retirement from the Corps of Engineers.

Harold T. Luskin was appointed as Deputy Associate Administrator for Manned Space Flight (Technical) on March 18, and on May 1, he was reassigned from this position to that of Director, Apollo Applications Program within the Office of Manned Space Flight. Mr. Luskin came to NASA from the Lockheed Missiles and Space Company.

On March 25, Thomas O. Paine was sworn in as Deputy Administrator of NASA, following Senate hearings and endorsement on February 6. Dr. Paine came from the General Electric Company with which he had been associated since 1949, in various technical and managerial capacities at the corporation's Schenectady (N.Y.) and Lynn (Mass.) laboratories. Since 1963, he had been General Manager

of the corporation's TEMPO, the Center for Advanced Studies, at Burbank, California.

Robert H. Curtin (Brig. General, USAF, Retired) was appointed as Director of Facilities, NASA, on May 1. Before retiring from the Air Force, General Curtin had headed the Air Force's facilities construction and civil engineering programs.

On June 1, James M. Beggs was appointed as Associate Administrator for Advanced Research and Technology, succeeding Dr. Mac C. Adams. Mr. Beggs came from the Westinghouse Corporation where he had been general manager of the corporation's Surface Division in Baltimore, Vice President of the Corporation's Defense and Space Center, and Director of Purchases and Traffic.

*Reassignments.*—On January 26, Edmond C. Buckley was appointed as a Special Assistant to the Administrator. He had been Associate Administrator for Tracking and Data Acquisition since November 1961.

Gerald M. Truszynski was appointed as Associate Administrator for Tracking and Data Acquisition on January 26. He had served as Deputy in this program since November 1961.

On February 11, Lee R. Scherer (Captain, USN, Retired) was appointed as Director, APOLLO Lunar Exploration Office, within the APOLLO Program Office, Office of Manned Space Flight. From late 1964 to early 1967, Captain Scherer had served as Manager, Lunar Orbiter Program. In February 1967, he became Assistant Director for Lunar Flight Program, Lunar and Planetary Programs Office, Office of Space Science and Applications.

Floyd L. Thompson ended his duties as Director, NASA Langley Research Center, on May 1, and was appointed a Special Assistant to the Administrator pending his retirement. This change was made to provide for the orderly transition of his duties to his successor. Dr. Thompson had served as Director of the center from May 1960. He was earlier Deputy Director of the center.

On May 1, Edgar M. Cortright became Director, NASA Langley Research Center. Mr. Cortright had been Deputy Associate Administrator for Space Science and Applications since November 1, 1961. Prior to that assignment, he had been Deputy Associate Administrator for Manned Space Flight (since October 16, 1967).

Charles W. Mathews was appointed as Deputy Associate Administrator for Manned Space Flight on May 1, succeeding Mr. Cortright. Mr. Mathews had been Program Manager, GEMINI (at the Manned Spacecraft Center, Houston, Texas) and Director, APOLLO Applications Program, Office of Manned Space Flight (since January 15, 1967).

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On May 1, Charles J. Donlan was appointed as Deputy Associate Administrator for Manned Space Flight (Technical), succeeding Harold T. Luskin. Mr. Donlan had served as Deputy Director, NASA Langley Research Center since April 1, 1961.

Henry J. Smith was appointed Deputy Associate Administrator for Space Science and Applications (Sciences) on May 5. He had been Deputy Director, Physics and Astronomy Programs Office, Office of Space Science and Applications, since May 5, 1966.

*Terminations.*—On January 5, Dr. Robert C. Seamans resigned from the position of Deputy Administrator, in which he had served since December 21, 1965. Previously (from September 1, 1960), Dr. Seamans had been the NASA Associate Administrator; he came to this Agency from the position of Chief Engineer, Missile Electronics and Controls Division of RCA.

Walter F. Boone (Admiral, USN, Retired) retired from the position of Assistant Administrator for Defense Affairs on January 1. Admiral Boone had served in this capacity since December 1, 1962.

Edmond C. Buckley retired from the position of Special Assistant to the Administrator on April 26. He had served in this capacity from January 26, 1968.

Dr. Mac C. Adams resigned from the position of Special Assistant to the Administrator on June 30. He had been appointed in this capacity June 1, 1968, pending his termination, and in order to provide orderly transition of his duties as Associate Administrator for Advanced Research and Technology (from October 4, 1965) to his successor, James M. Beggs.

### Status of Personnel Force

These figures represent total employment (including temporaries) for the periods ending December 31, 1967 and June 30, 1968.

	December 1967	June 1968
Headquarters-----	2, 176	2, 310
Ames Research Center-----	2, 171	2, 197
Electronics Research Center-----	785	950
Flight Research Center-----	607	622
Goddard Space Flight Center-----	3, 752	4, 073
Kennedy Space Center-----	2, 782	3, 044
Langley Research Center-----	4, 211	4, 219
Lewis Research Center-----	4, 623	4, 583
Manned Spacecraft Center-----	4, 728	4, 956
Marshall Space Flight Center-----	7, 288	6, 935
NASA Pasadena Office-----	87	79
Space Nuclear Propulsion Office-----	117	108
Wallops Station-----	509	565
Western Support Office-----	103	
Total-----	33, 939	34, 641

### **Inventions and Contributions Board**

NASA's Inventions and Contributions Board has three principal functions. First, it reviews petitions for waiver of patent rights that have been submitted by NASA contractors, recommends the disposition of each petition, and sends its recommendations to the Administrator of NASA for final decision. Second, it considers and evaluates the merits of inventions and other scientific and technical contributions reported by NASA employees and NASA contractor employees. Following its consideration, the Board recommends to the Administrator that monetary awards be granted for qualified inventions and contributions, specifying an equitable amount for the award. In addition, the Board is authorized to grant monetary awards of up to \$5,000 (Government Employees' Incentive Awards Act of 1954) for inventions made by employees of the U.S. Government. Third, in addition to granting awards to NASA contractor employees, the Board also considers applications for awards for scientific and technical contributions that are received from members of the general public, both foreign and domestic. (A listing of the present members of the Board appears in appendix F.)

#### **Board Actions on Petitions for Patent Waiver**

The staff of the Board analyzed, evaluated, and presented to the Board 46 petitions for waiver of patent rights to individual inventions, as authorized by Section 305 of the Space Act. The Board's findings and recommendations were sent to the Administrator, who granted 34 petitions and denied 12 petitioners and decisions are listed in appendix G). Thirteen petitions for blanket waiver of patent rights to all inventions which may be made during contract performance, were also considered by the Board and, of these, the Administrator granted nine and denied four (petitioners and decisions listed in appendix H).

In addition, the Administrator granted 12 petitions for patent waiver which had been recommended by an Advance Review Panel of the Board prior to placement of contracts (petitioners and decisions listed in appendix H). This panel also considered seven other petitions for waiver and recommended that they not be granted.

Altogether, the Board and the Administrator acted on 71 petitions for waiver.

#### **Summary on Commercialization of Waived Inventions**

In April, the staff of the Board prepared its first annual edition of "A Summary of Reports on Commercialization Activities of Patent Waiver Grantees" and, accompanied by an analysis, it was sent to the

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Office of the Administrator. This summary was based on reports submitted by contractors to whom waiver of title to patents had been granted by NASA prior to 1967. It described in detail the progress that had been made by these contractors in commercializing the waived inventions. The report showed that some of the inventions are already commercialized, many are in the process of being developed and marketed, and a few appear to have a slight chance of being commercialized.

### **Publication of Patent Waiver Recommendations**

Under the supervision of the Board's staff, a new supplement to the publication entitled "PETITIONS FOR PATENT WAIVERS—Findings of Fact and Recommendations of NASA's Inventions and Contributions Board", was compiled and published. The new supplement, identified as NHB 5500.1A—Change 3, was published in June 1968 and is available for purchase from the Superintendent of Documents.

### **Monetary Awards for Inventions and Contributions**

*Space Act (Section 306) Awards.*—Under the authority of Section 306 of the Space Act, the Board recommended the granting of the following types of awards: (1) The Administrator granted monetary awards of \$250 and above for 20 cases involving inventions or contributions; information concerning the individual cases appears in appendix I; (2) a minimum award of \$25 was granted to each of 421 individuals for developing and reporting scientific and technical innovations that were subsequently published as NASA Tech Briefs; and (3) a minimum award of \$50 was granted to each of 41 individuals who participated in creating and reporting inventions upon which U.S. patent applications were later filed. The total amount of money awarded under the Space Act authority was \$22,500.

*Incentive Act Awards.*—Under the provisions of the Government Employees' Incentive Awards Act of 1954, the Board granted awards to 111 government employees for 74 cases involving inventions and contributions. The number of award cases submitted by each NASA Research Center, the title of the contribution, and the names of the individuals who received awards appear in appendix J. The total amount of money awarded under the authority of the Incentive Awards Act was \$21,650.

### **Oral Hearings Before the Board**

The Board held one hearing in connection with an application for an award for a technical contribution submitted by a private citizen.

Following evaluation and consideration, the Board recommended that no monetary award be granted.

### **Organizational Improvements**

Early in this period, NASA made a number of managerial improvements to strengthen the systems employed by the Administrator for top level communication and decisionmaking. An Assistant Administrator for Management Development was appointed to concentrate on the development and dissemination of policy and action processes. Management delegations were issued by the Administrator to specify the authority of senior officials with respect to major decisionmaking processes. Significant new policy documents were issued, defining the use of phased project planning for future programs and establishing new policy for tying in Project Approval Documents (PAD's) with year-by-year budget levels as approved by the Congress.

Through these new policies, an integrated structure of planning, approval, and funding should bring to the Administrator for his approval defined program options which reflect NASA-wide administrative considerations as well as their primary program intentions. Program approval should also be more flexibly tied to the budget process as it proceeds through the Congressional approval cycle.

As a further strengthening of executive level communication, NASA's senior Headquarters managers now meet regularly as a Management Council to consider problems either in current operations or of importance in the near term future. Also, once each month, a General Management Review is held for other senior staff people who need to be familiar with the broad aspects of agency management. Each Associate Administrator holds his own status review in advance as preparation for these General Management Reviews.

Several significant organizational changes were also made. The NASA Safety Office was substantially reorganized and revamped under a new Director, who reports directly to the Associate Administrator for Organization and Management. Emphasis was being placed on helping line managers throughout NASA to achieve the best possible safety program. Also being emphasized were reviews, inspections, and appraisals to assure NASA's top management that safety requirements are being effectively satisfied.

Of equal significance was the formal beginning (in January) of the activities of the Aerospace Safety Advisory Panel (ASAP). This panel was created by the Congress in the NASA Appropriation Act of 1968. After careful consideration by a special interim advisory group, the Administrator approved a charter for the ASAP and appointed

its members under Dr. Charles D. Harrington, President of Douglas United Nuclear Incorporated, as Chairman.

The Panel will function in an advisory capacity to the Administrator, and through him, to those organizational elements responsible for management of the NASA safety activities. The Panel will be provided with all information required to discharge its advisory responsibilities as they pertain to both NASA and contractor safety activities. This information is to be made available through appropriate reports and on-site visits which will permit the Panel to evaluate the key safety elements of on-going and planned activities. The ASAP will evaluate all facets of safety within NASA and report its findings and recommendations to the Administrator.

A new Headquarters Communications Center was established as a part of the Executive Secretariat. This Center is to provide a "data bank" of management information, communications, and correspondence for use by the Office of the Administrator and other management people.

### **Financial Management**

The Agency made a number of significant improvements in its financial management functions and activities. One of the more important ones related to changes in its method of submitting budget justification materials to Congress.

#### **Improvements in Presentation of the Budget**

Congressional committees accepted NASA's proposal to submit only four volumes of budget justification materials in support of FY 1969 budget estimates. Three of these volumes related to three individual appropriations, and the remaining volume contained summary data of all three. Previously, the Agency had submitted three additional volumes organized by program office, with extractions of appropriate materials from the appropriation volumes. The change made possible a more timely submission of NASA's FY 1969 budget justification materials and significantly reduced related printing costs.

A Special Analysis of Automatic Data Processing Equipment (ADPE) was included in NASA's annual submission of budget justification materials to Congress. This presentation included funding, inventory, personnel, and other selected data on NASA's ADP activities. In the FY 1969 budget submission, the ADPE special analysis tables were organized to achieve a more concise presentation. This substantially reduced the bulk of the material presented and greatly simplified the Congressional review process.

### **Property Accounting**

As a prerequisite for obtaining the Comptroller General's approval of NASA's overall accounting system, the Agency revised the Financial Management Manual part on industrial property to include space hardware. A related handbook covering contractors' semiannual reporting of NASA-owned property and space hardware was developed and submitted to the U.S. General Accounting Office. The contractor reporting requirements had been coordinated with industry and approved by the Bureau of the Budget, and the handbook has since been distributed to NASA contractors and field installations.

### **NASA-Wide User-Charges Inventory**

NASA placed increased emphasis on its user-charges program to make certain that an adequate charge is imposed in all applicable situations. A significant accomplishment in this regard was the development of a NASA-Wide User-Charges Inventory. This inventory, containing a complete list of NASA user-charge categories and the range of rates for each, was sent to each installation for comparison with local rates (and possible adjustment), for review for possible services and activities which are furnished without charge. A requirement for an annual review and updating of this inventory was established in the NASA Financial Management Manual.

### **Schedule of Fees**

In accordance with Public Law 90-23, "Freedom of Information Act," a schedule was published in the Federal Register, showing NASA's charges for information furnished to the public. This schedule replaces a temporary one published in July 1967.

### **Fiscal Year 1969 Program**

Table 10-1 shows the level of effort in research and development, construction of facilities, and administrative operations for fiscal year 1969, as authorized by the National Aeronautics and Space Administration Authorization Act of 1969.

### **Financial Reports, June 30, 1968**

Table 10-2 shows fund obligations and accrued costs incurred during the 6 months ended June 30, 1968. Appended to the table is a summary by appropriation showing current availability, obligations against this availability, and unobligated balances as of June 30, 1968.

Table 10-3 shows NASA's consolidated balance sheet as of June 30, 1968, as compared to that of December 31, 1967. Table 10-4 summarizes the sources and applications of NASA's resources during the six months ended June 30, 1968. Table 10-5 provides an analysis of the net change in working capital disclosed in Table 10-4.

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**Table 10-1. NASA appropriation authorizations, fiscal year 1969**

[In thousands]

Research and development:	
Apollo	\$2,025,000
Apollo applications	253,200
Advanced missions	2,500
Physics and astronomy	136,900
Lunar and planetary exploration	92,300
Bioscience	33,000
Space applications	98,700
Launch vehicle procurement	115,700
Sustaining university program	9,000
Space vehicle systems	31,800
Electronics systems	35,500
Human factor systems	19,700
Basic research	21,000
Space power and electric propulsion systems	42,300
Nuclear rockets	55,000
Chemical propulsion	30,200
Aeronautical vehicles	74,900
Tracking and data acquisition	289,800
Technology utilization	3,800
Total, research and development	3,370,300
Construction of facilities	39,600
Administrative operations	603,173
<b>Total</b>	<b>4,013,073</b>

**Cost Reduction Program**

NASA's Cost Reduction Program comprises two major efforts to improve the Agency's internal and contractor efficiency and economy. The Internal Cost Reduction Program encompasses ten field installations and all of the principal Headquarters program and staff offices. The NASA Contractor Cost Reduction program includes 38 of the Agency's major contractors who voluntarily participate in the formal reporting program. There is no overlapping or duplication between the two programs, although the concepts, standards, and criteria are quite similar.

NASA's Internal Cost Reduction Program yielded savings of \$95,-306,000, and its Contractor Cost Reduction Program reduced costs by \$89,735,000 during this period (second half of FY 1968).

The NASA Deputy Administrator is responsible for managing the Program. The Cost Reduction Board is responsible for the program's day-to-day operation through the Headquarters Cost Reduction Office. The Board, chaired by the Associate Deputy Administrator, is comprised of the Associate Administrator for Organization and Manage-

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Table 10-2. Status of appropriations as of June 30, 1968

	[In thousands]	<i>Six months ended June 30, 1968</i>	
		<i>Obligations</i>	<i>Accrued costs</i>
<i>Appropriations</i>			
Research and development:			
Apollo-----	\$1,085,207	\$1,307,867	
Apollo applications-----	85,989	70,313	
Advanced missions-----	1,569	1,059	
Gemini-----	2,251	3,252	
Completed missions-----	(22)	(26)	
Physics and astronomy-----	65,441	89,096	
Lunar and planetary exploration-----	58,591	62,249	
Launch vehicle procurement-----	89,351	83,419	
Bioscience-----	18,247	19,886	
Space applications-----	37,478	49,393	
Space vehicle systems-----	20,649	19,708	
Electronics systems-----	26,332	20,949	
Human factor systems-----	11,335	9,720	
Basic research-----	12,380	11,768	
Space power and electric propulsion systems-----	25,222	29,925	
Nuclear rockets-----	20,898	23,061	
Chemical propulsion-----	18,680	16,639	
Aeronautics-----	39,240	32,991	
Tracking and data acquisition-----	145,699	164,936	
Sustaining university program-----	10,202	18,987	
Technology utilization-----	1,610	2,195	
Operations-----	(98)	(79)	
Reimbursable-----	25,511	36,129	
Total, research and development-----	1,801,762	2,073,437	
Construction of facilities-----	33,915	59,028	
Administrative operations-----	322,104	336,372	
<b>Totals-----</b>	<b>2,157,781</b>	<b>2,468,837</b>	
<i>Appropriation summary</i>	<i>Current availability<sup>1</sup></i>	<i>Total obligations</i>	<i>Unobligated balance</i>
Research and development-----	\$2,112,911	\$1,801,762	\$311,149
Construction of facilities-----	103,184	33,915	69,269
Administrative operations-----	322,234	322,104	130
<b>Totals-----</b>	<b>2,538,329</b>	<b>2,157,781</b>	<b>380,548</b>

<sup>1</sup> The availability listed includes authority for anticipated reimbursable orders.

ment, the Assistant Administrator for Industry Affairs, and the Deputy Associate Administrator (Management) of the Office of Manned Space Flight.

The Administrator periodically reviews the progress and objectives of the Program with the Cost Reduction Board. On March 6 and April 26, the Administrator reported to the President on the results and accomplishments achieved under the NASA-Internal and NASA-

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**Table 10-3. NASA Comparative Consolidated Balance Sheet—June 30, 1968 and December 31, 1967**

[In millions]

	ASSETS	
	<i>June 30, 1968</i>	<i>December 31, 1967</i>
Cash:		
Funds with U.S. Treasury-----	\$1,996.2	\$4,428.9
Accounts receivable:		
Federal agencies-----	18.0	37.3
Other-----	1.4	.8
Total-----	19.4	38.1
Inventories:		
NASA-held-----	35.3	39.7
Contractor-held-----	294.2	252.9
Total-----	329.5	292.6
Advances and prepayments:		
Federal agencies-----	12.3	10.4
Other-----	16.4	27.1
Total-----	28.7	37.5
Fixed assets:		
NASA-held-----	3,134.0	2,806.4
Contractor-held-----	692.7	595.3
Construction in progress-----	585.6	792.3
Total-----	4,412.3	4,194.0
Total assets-----	6,786.1	8,991.1
LIABILITIES AND EQUITY		
Liabilities:		
Accounts payable:		
Federal agencies-----	\$127.4	\$120.7
Other-----	541.0	564.6
Total-----	668.4	685.3
Accrued annual leave-----	34.4	35.2
Total liabilities-----	702.8	720.5
Equity:		
Net investment-----	4,070.8	3,819.4
Undisbursed allotments-----	1,965.5	3,198.0
Unapportioned and unallotted appropriation-----	141.6	1,407.7
Total-----	6,177.9	8,425.1

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Table 10-3. NASA Comparative Consolidated Balance Sheet—June 30, 1968 and December 31, 1967—Continued

	[In millions]	
	June 30, 1968	December 31, 1967
Less reimbursable disbursing authority uncollected...	(94.6)	(154.5)
Total equity-----	6,083.3	8,270.6
Total liabilities and equity-----	6,786.1	8,991.1

Contractor Programs. Reports subsequent to the end of this period showed that during FY 1968, the Internal Program achieved savings of \$140,484,000 compared with a goal of \$140 million, and the NASA-Contractor Program reported savings of \$183,674,000, a total savings for both programs of \$324,158,000. This is less than the reported results a year ago when the Agency's general level of activity and funding was higher. Some declining trend was noted during the past twelve months in the total amount of cost reduction actions reported by both NASA internal and contractor reporting activities. This lessening of activity can be attributed to the completion of several major NASA flight projects, such as Gemini, Lunar Orbiter, and Surveyor, and to the reductions in the NASA budget.

However, periodic on-site reviews of installation and contractor programs continued. During this period, reviews and re-evaluations of 5 NASA installation programs were conducted and 10 evaluations of contractor corporate and plant programs were completed. The results indicate that support of the programs by NASA operating management and by corporate management was continuing at a high level. Also, the information gained from these reviews is used to appraise top management of improvements which the installations and contractors have made or could make in the management and operation of their programs.

Quarterly review meetings and seminars continue to provide the principal means of direct communication of ideas and resolution of problems between Cost Reduction Officers of the various installations and the Cost Reduction Office. The review and shirt-sleeve seminar held at Goddard Space Flight Center in May led to an improved method of establishing NASA's cost reduction goals. It also opened the way toward increased activity in new areas of cost savings opportunities.

The potential goal for FY 1969 under the Internal Cost Reduction Program is \$125 million; and, although no formal goals are set for contractors, prospective savings during FY 1969 will probably amount to \$160 million.

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Table 10-4. Resources provided and applied—6 months ended June 30, 1968

[In millions]

RESOURCES PROVIDED		
Revenues-----	\$32.8	
Decrease in working capital (Table 10-5)-----	2,406.4	
Total resources provided-----	2,439.2	
 RESOURCES APPLIED		
	<i>Total costs 6 months ended June 30, 1968</i>	<i>Less costs applied to assets</i>
Operating costs:		
Research and development-----	\$2,073.4	\$157.4 1,916.0
Construction of facilities-----	59.0	57.1 1.9
Administrative Operations-----	336.4	15.2 321.2
Total-----	2,468.8	229.7 -----
Total operating costs-----	2,239.1	
Increase in fixed assets:		
NASA-held-----		327.6
Contractor-held-----		97.4
Construction in progress-----		(206.7)
Total increase in fixed assets-----		218.3
Property transfers and retirements—net-----		(21.0)
Administrative Operations appropriation re- turned to Treasury-----		2.8
Total resources applied-----		2,439.2

Table 10-5. Net change in working capital—6 months ended June 30, 1968

[In millions]

	<i>June 30, 1968</i>	<i>December 31, 1967</i>	<i>Increase or (Decrease)</i>
Current assets:			
Funds with U.S. Treasury-----	\$1,996.2	\$4,428.9	(\$2,432.7)
Accounts receivable-----	19.4	38.1	(18.7)
Inventories-----	329.5	292.6	36.9
Advances and prepayments-----	28.7	37.5	(8.8)
Total current assets-----	2,373.8	4,797.1	(2,423.3)
Current liabilities:			
Accounts payable-----	668.4	685.3	(16.9)
Working capital-----	1,705.4	4,111.8	-----
Decrease in working capital-----			(2,406.4)

### **Contract Adjustment Board**

The Contract Adjustment Board exercises the authority of the Administrator in considering requests by NASA contractors for equitable contractual relief under Public Law 85-804, where the contractor has no administrative legal remedy available. The Board has five members appointed by the Administrator. (Members of the Board are listed in appendix K.)

The types of equitable relief which may be authorized by the Board include, by way of example, the correction of mistakes or ambiguities in contracts and the formalization of informal commitments. Also, the Board has the authority to amend a contract without consideration, where the contractor suffers a loss as a result of Government action, or where a loss is found to impair the productive ability of a contractor deemed essential to the national defense. The Board's procedures are published in Title 41, Code of Federal Regulations, Part 18-17.

During the period, the Board acted on one request by a contractor, denying the relief requested. However, the contractor has filed a request for reconsideration of the Board's decision. During the same period, the Board also had one other request under consideration.

The Board submits an annual report to Congress of all actions taken under the authority of P.L. 85-804 during the preceding calendar year.

### **Board of Contract Appeals**

This Board was established by the Administrator to adjudicate appeals by NASA contractors, arising under the "Disputes" clause of NASA contracts. The Board has six members appointed by the Administrator with one vacancy. (Members of the Board are listed in appendix L.)

During the period, 10 new appeals were filed with the Board. Also, the Board disposed of 20 appeals (most of which were filed prior to January 1, 1968). At period's end, the Board had 48 appeals pending on its docket, compared with 72 appeals pending a year earlier.

### **Procurement and Supply Management**

NASA continued to issue new and revised procurement policies and procedures to improve the procurement process and to help attain national goals such as the employment of disadvantaged persons. Contract administration agreements with the Department of Defense were being studied for possible improvements, and incentive contracting concepts were under constant analysis and evaluation.

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### **Selecting a Grant or Contract as the Research Support Instrument**

NASA issued a series of procurement guidelines outlining the criteria for selecting either a grant or a contract as the research support instrument for dealing with nonprofit institutions of higher education or nonprofit organizations whose primary purpose is to conduct scientific research. Under these guidelines, Contracting Officers must consider certain specific factors before selecting the appropriate research support instrument based upon an unsolicited proposal. They must take into account NASA's policies for dealing with universities, the special needs of the technical office supporting the research, the nature of the proposed research, the manner in which it will be performed, and the nature and extent of technical direction and management control planned by NASA. Other significant factors which generally indicate whether a grant or a contract will be used are also to be taken into consideration.

### **Small Business**

Seventeen Interdepartment Federal Procurement Seminars were held during the first 6 months of 1968. NASA was represented at all of these meetings which were held in 17 cities involving 9 states. NASA Headquarters and field personnel also participated in locally-sponsored procurement seminars and attended Technology Utilization and Small Business & Economic Utilization Council meetings during the same period.

NASA instituted a Small Business Set-Aside Program within the Small Business Subcontracting Program. Through this program, selected major prime contractors, by agreement without cost to the Government, will set aside for exclusive small business participation those subcontracts considered appropriate for that action under the criteria set forth in the NASA Procurement Regulation. This program activity is to be expanded to include additional prime contractors.

The Small Business Administration may assign representatives to any procurement office to review proposed procurements for the purpose of initiating set-asides, recommending component breakout opportunities, and proposing solicitation of new qualified small business concerns.

To provide effective working arrangements between the SBA representatives and NASA personnel, the NASA Procurement Regulation was revised. New procedures were developed for the referral of proposed small business awards to the Small Business Administration for a Certificate of Competency. These procedures outline the steps involved in seeking SBA review of capacity and credit of a small business concern being considered for a contract award. They also provide for appeal to the NASA Headquarters in cases where agreement

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cannot be reached between the Contracting Officer and the SBA field office.

### **Employment of Disadvantaged Persons in Labor Surplus Areas**

NASA issued new policies and procedures dealing with employment of disadvantaged persons in sections of concentrated unemployment or underemployment. These policies implement Defense Manpower Policy No. 4 (Revised), October 16, 1967, and U.S. Department of Labor Regulations. Defense Manpower Policy No. 4 states that it is the policy of the Government to encourage placing contracts and facilities in labor surplus areas and to assist such areas in making the best use of their available resources.

Under this policy, additional preference in the performance of set-asides is given to concerns certified by the Secretary of Labor as eligible for preference. These concerns acquire such eligibility by agreeing to perform portions of the contracts in areas of concentrated unemployment or underemployment. They also agree to comply with regulations of the Secretary of Labor with respect to employment of disadvantaged persons.

### **New Progress Payment Rates**

NASA revised its contract financing policies by authorizing an increase in progress payment rates. This policy authorizes customary progress payments to be made up to 80 percent of total incurred costs and up to 85 percent for small business concerns (previously, these percentages were 70 percent and 75 percent, respectively) for contracts that were entered into on or after April 1, 1968.

### **Warranties**

Under a new NASA policy, procurement personnel receive comprehensive guidance on the use of warranties. This policy explains that a warranty clause gives the Government a contractual right to assert claims of deficiencies in the supplies or services furnished. Such claims would be over and above the claims based on the acceptance provisions of the contract. The policy also sets forth the provisions governing the use and scope of the warranty clause.

It includes instructions on the pricing aspects of fixed-price incentive warranty provisions; it provides for the evaluation of NASA contractors' policies and procedures for obtaining warranties from their suppliers; and it presents examples of the following clauses: (1) the "Warranty of Supplies" clause which is authorized for use in fixed-price supply contracts with modification necessary to make it applicable to a fixed-price incentive contract; (2) the "Warranty of Services" clause authorized for use in fixed-price service contracts; (3) the "Correction of Deficiencies" clause authorized for use in fixed-price

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type supply and service, and in research and development contracts where performance specifications or design are of major importance; and (4) the "Warranty of Construction" clause used in fixed-price type construction contracts.

### **Equal Employment Opportunity—Assurance of Nonsegregated Facilities**

NASA issued new policies and procedures to implement Secretary of Labor Order No. 169, "Elimination of Segregated Facilities by Government Contractors and Subcontractors," by adding additional provisions to Part 12, Subpart 8 of its regulations.

Under this policy, Government contractors are obligated to eliminate any written or oral policies and practices they may have which require segregation on a basis of race, creed, color, or national origin. Contractors are also required to ensure that facilities are provided for their employees in such a manner that segregation cannot result. They must also guarantee that their employees are not assigned to duties at any location under the employer's control where facilities are segregated. To implement this policy, the following provisions were added to Part 12, Subpart 8 of the NASA Procurement Regulation: "Note the Certification of Nonsegregated Facilities in this Solicitation," "Certification of Nonsegregated Facilities," and "Notice to Prospective Subcontractors of Requirement for Certifications on Nonsegregated Facilities."

These provisions are required to be included in Invitation for Bid's, Requests for Proposals, and Agreements not exempt from the provisions of the Equal Opportunity clause. The "Certification of Nonsegregated Facilities by Subcontractors and Federally Assisted Construction Contractors" clause must be included in all contracts and agreements with applicants for federally assisted construction contracts which include the Equal Opportunity clause.

### **Cost of Pricing Data, PL 87-653, "Truth in Negotiation"**

The NASA Procurement Regulation was substantially revised to place increased emphasis on the implementation of PL 87-653, "Truth in Negotiation." Key changes in the NASA regulation are: (1) the right for the Government to perform post-award cost performance audits for the single purpose of determining whether or not defective cost or pricing data were submitted; (2) the requirement for the contractor to submit, either actually or by specific identification in writing, certified cost or pricing data; (3) the requirement for the Record of Negotiation to reflect the extent to which reliance was not placed on factual cost or pricing data submitted and the extent to which these data were not used by the contracting officer in determining his total price objective and in negotiating the final price; and (4) the

requirement for all contractors to submit their cost proposals using DD Form 633, Contract Price Proposal, which gives instructions for proper cost or pricing data disclosure.

To make certain that its personnel fully understand and comply with the revised regulation, NASA sponsored training seminars at eight NASA Field centers. Certain centers were holding in-house training on cost or pricing data requirements, and all centers were being encouraged to hold further training as required.

**NASA/DOD Agreements for Performance of Contract Administration Services**

NASA and DOD began a joint effort to consolidate, expand, and revise existing contract administration services agreements into a single new agreement. This effort should further promote maximum NASA use of DOD contract management resources. It is consistent with the policy of promoting uniform policies and procedures in the field administration of NASA and DOD contracts.

**Continued NASA Participation in DOD Contract Management Reviews of Contract Administration Offices**

NASA participation in DOD's management reviews of that Department's major contract administration activities, which began in July 1967, continued throughout this report period. NASA participates in such reviews when the activities involved have substantial NASA contract administration workloads. This participation enables the agency to make certain that the contract administration services provided by DOD are satisfactory. The DOD contract administration services support provided to NASA cost the agency about \$25,000,000 for FY 1968.

**Improved Procurement Methods**

As a major user of magnetic tapes, NASA has led the way in developing standard specifications for high quality tapes. By preparing detailed specifications and consolidating requirements for competitive bids, the Agency saved more than \$1,000,000 in procurement costs.

**Incentive Contracting**

NASA started the period with 273 incentive contracts under administration (target value, \$6.2 billion). As of June 30, NASA had 285 incentive contracts valued at \$6.7 billion.

Most of NASA's 125 incentive contractors have Cost Plus Incentive Fee contracts (CPIF). CPIF contracts account for approximately 45 percent of the number of incentive contracts and approximately 50 percent of the dollar volume. Because the Fixed Price Incentive (FPI) contract calls for relatively firm design, specification, and performance requirements with few technical uncertainties, this type

is generally not appropriate for NASA's space development programs. As a result, FPI contracts account for only about 10 percent of the number and about 5 percent of the dollar volume of incentives. Cost Plus Award Fee type contracts (CPAF) represent the second largest group of incentives, accounting for about 45 percent of the number of contracts and 45 percent of the dollar volume.

NASA continued to examine and re-evaluate the effectiveness of incentive procedures in research and development contracting. The quarterly reviews of the largest contracts and a sampling of smaller contracts indicated that these procedures were sound. Approximately 96 percent of the dollar volume of incentives and only 40 percent of the number of contracts are found in those incentives over \$5 million each, and 22 incentive contracts each above \$50 million account for slightly over 70 percent of the dollar volume. The group of the largest contracts is staying within 2 percent to 3 percent of target cost.

NASA's Project Managers indicate that there have been significant contractor improvements in the larger contracts in the areas of management, better communication between Government and contractor personnel (especially noticeable in award fee contracts), schedule improvements, and contractor efforts to reduce costs without compromising performance. Overall, the greatest improvement noted was in improved definition of both the contract and the scope of work.

#### **Summary of Contract Awards**

NASA's procurement for the last 6 months of Fiscal Year 1968 (this report period) totaled \$1,930 million. This is \$64 million more than was awarded during the corresponding period of FY 1967.

Approximately 81 percent of the net dollar value was placed directly with business firms, 6 percent with educational and other non-profit institutions, 4 percent with the California Institute of Technology for operation of the Jet Propulsion Laboratory, and 9 percent with or through other Government agencies.

#### **Contracts Awarded to Private Industry**

Ninety percent of the dollar value of procurement requests placed by NASA with other Government agencies resulted in contracts with industry awarded by those agencies on behalf of NASA. In addition, about 77 percent of the funds placed by NASA under the Jet Propulsion Laboratory contract resulted in subcontracts or purchases with business firms. In short, about 92 percent of NASA's procurement dollars was contracted to private industry.

Sixty-four percent of the total direct awards to business represented competitive procurements, either through formal advertising or competitive negotiation. An additional 9 percent represented actions on follow-on contracts placed with companies that had pre-

viously been selected on a competitive basis to perform the research and development on the applicable project. In these instances, selection of another source would have resulted in additional cost to the Government by reason of duplicate preparation and investment. The remaining 27 percent included contracts for facilities required at contractors' plants for performance of their NASA research and development effort, contracts arising from unsolicited proposals offering new ideas and concepts, contracts employing unique capabilities, and procurements of sole-source items.

Small business firms received \$105 million, or 7 percent of NASA's direct awards to business. However, most of the awards to business were for large continuing research and development contracts for major systems and major items of hardware. These are generally beyond the capability of small business firms on a prime contract basis. Of the \$34 million of new contracts of \$25,000 and over awarded to business during the six months, small business received \$45 million, or 13 percent.

In addition to the direct awards, small business received substantial subcontract awards from 83 of NASA's prime contractors participating in its Small Business Subcontracting Program. Total direct awards plus known subcontract awards aggregated \$226 million, or 14 percent of NASA's total awards to business during the last half of FY 1968.

#### **Geographical Distribution of Prime Contracts**

Within the United States, NASA's prime contract awards were distributed among 49 States and the District of Columbia. Business firms in 43 States and the District of Columbia, and educational institutions and other nonprofit institutions in 48 States and the District of Columbia, participated in the awards. Two percent of the awards went to labor surplus areas located in 13 States.

#### **Subcontracting**

Subcontracting effected a further distribution of the prime contract awards. NASA's major prime contractors located in 25 States and the District of Columbia reported that their larger subcontract awards on NASA effort had gone to 1,234 subcontractors in 42 States and the District of Columbia, and that 49 percent of these subcontract dollars had crossed state lines.

#### **Major Contract Awards**

Among the major research and development contract awards by NASA during the last six months of Fiscal Year 1968 were the following:

1. North American Rockwell Corp., Downey, Calif. NAS 9-150. Design, develop and test Apollo command and service module. Awarded \$197 million; cumulative awards \$3,015 million.

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2. Grumman Aircraft Engineering Corp., Bethpage, N.Y. NAS 9-1100. Development of Apollo lunar module. Awarded \$120 million; cumulative awards \$1,583 million.
3. North American Rockwell Corp., Downey, Calif. NAS 7-200. Design, develop, fabricate and test the S-II stage of the Saturn V vehicle and provide launch support services. Awarded \$83 million; cumulative awards \$1,129 million.
4. McDonnell Douglas Corp., Santa Monica, Calif. NAS 7-101. Design, develop and fabricate the S-IVB stage of the Saturn V vehicle and associated ground support equipment and provide launch support services. Awarded \$72 million; cumulative awards \$959 million.
5. General Electric Company, Huntsville, Ala. NASW-410. Apollo checkout equipment, related engineering design, quality and data management and engineering support; support services to Mississippi Test Facility. Awarded \$60 million; cumulative awards \$670 million.
6. The Boeing Company, New Orleans, La. NAS 8-5608. Design, develop and fabricate the S-IC stage of the Saturn V vehicle, construct facilities in support of the S-IC stage and provide launch support services. Awarded \$47 million; cumulative awards \$1,199 million.
7. International Business Machines Corp., Huntsville, Ala. NAS 8-14000 Fabrication, assembly and checkout of instrument units for Saturn I and V vehicles. Awarded \$35 million; cumulative awards \$266 million.
8. Chrysler Corporation, New Orleans, La. NAS 8-4016. Fabricate, assemble, checkout and static test Saturn S-IB stage; provide product improvement program and spare parts support; modify areas of Michoud Plant assigned to contractor; provide launch support services. Awarded \$29 million; cumulative awards \$457 million.
9. North American Rockwell Corp., Canoga Park, Calif. NAS 8-19. Develop and procure 200,000-pound thrust J-2 rocket engine with supporting services and hardware. Awarded \$28 million; cumulative awards \$611 million.
10. Aerojet General Corp., Sacramento, Calif. SNP-1. Design, develop and produce a nuclear powered rocket engine (NERVA). Awarded \$27 million; cumulative awards \$450 million.
11. The Boeing Company, Washington, D.C. NASW-1650. Apollo/Saturn V technical integration and evaluation. Awarded \$27 million; cumulative awards \$52 million.
12. Bendix Corporation, Owings Mills, Md. NAS 5-10750. Maintenance and operation of the Manned Space Flight Network. Awarded \$27 million (new contract).
13. North American Rockwell Corp., Canoga Park, Calif. NAS 8-18734. Fabrication and delivery of F-1 engines; provide supporting services and hardware. Awarded \$20 million; cumulative awards \$104 million.
14. Bendix Corporation, Kennedy Space Center, Fla. NAS 10-1600. Apollo launch support services at Kennedy Space Center. Awarded \$20 million; cumulative awards \$76 million.
15. Bendix Corporation, Ann Arbor, Mich. NAS A-5829. Apollo lunar surface experiments package. Awarded \$18 million; cumulative awards \$51 million.
16. General Dynamics Corp., San Diego, Calif. NAS 3-8711. Management and engineering services in support of Centaur program. Awarded \$16 million; cumulative awards \$38 million.
17. Trans World Airlines, Kennedy Space Center, Fla. NAS 10-12142. Provide base support services at Kennedy Space Center. Awarded \$15 million; cumulative awards \$82 million.

## PERSONNEL, MANAGEMENT, PROCUREMENT, SUPPORT FUNCTIONS 163

18. Catalytic-Dow (joint venture), Kennedy Space Center, Fla. NAS 10-4873. Facilities support services. Awarded \$13 million; cumulative awards \$19 million.
19. Martin Marietta Corp., Denver, Colo. NAS 8-24000. Apollo applications program for the payload integration program. Awarded \$12 million (new contract).
20. Brown/Northrop (joint venture), Houston, Tex. NAS 9-7572. Operational support of laboratories and test facilities—Apollo Spacecraft. Awarded \$11 million (new contract).

### Major Contractors

The 25 contractors receiving the largest direct awards (net value) during the first six months of FY 1968 were as follows:

<i>Contractor and Place of contract performance</i>	<i>Thousands</i>
1. North American Rockwell Corp., Downey, Calif.*-----	\$356,675
2. Grumman Aircraft Engrg. Corp., Bethpage, N.Y-----	136,543
3. McDonnell Douglas Corp., Santa Monica, Calif.*-----	95,965
4. General Electric Company, Daytona Beach, Fla.*-----	87,006
5. Bendix Corp., Owings Mills, Md.*-----	82,129
6. Boeing Company, New Orleans, La.*-----	80,296
7. International Business Machines Corp., Huntsville, Ala.*-----	67,410
8. Aerojet-General Corp., Sacramento, Calif.*-----	38,001
9. Chrysler Corporation, New Orleans, La.*-----	31,037
10. General Dynamics Corp., San Diego, Calif.*-----	30,855
11. Radio Corporation of America, Princeton, N.J.*-----	30,426
12. LTV Aerospace Corp., Dallas, Tex.*-----	25,850
13. Lockheed Aircraft Corp., Houston, Tex.*-----	23,439
14. TRW, Inc., Houston, Tex.*-----	20,942
15. Sperry Rand Corp., Huntsville, Ala.*-----	19,595
16. Martin Marietta Corp., Denver, Colo.*-----	19,195
17. United Aircraft Corp., Windsor Locks, Conn.*-----	16,672
18. Trans World Airlines, Inc., Kennedy Space Center, Fla.*-----	15,610
19. Philco-Ford Corp., Houston, Tex.*-----	13,981
20. Catalytic-Dow (joint venture), Kennedy Space Center, Fla-----	12,771
21. Control Data Corp., Minneapolis, Minn.*-----	10,913
22. Brown/Northrop (joint venture), Houston, Tex-----	10,868
23. Northrop Corporation, Huntsville, Ala.*-----	10,240
24. Honeywell, Inc., St. Petersburg, Fla.*-----	9,740
25. General Precision Systems, Inc., Houston, Tex.*-----	8,080

\*Awards during the period represent awards on several contracts which have different principal places of performance. The place shown is that which has the largest amount of the awards.

### Labor Relations

During this period strikes on construction contracts at all NASA Centers caused a loss of 2,066 man-days. During the preceding 6 months, such strikes caused the loss of only 1,019 man-days. On Cape Kennedy, 645 man-days were lost during the first half of 1968, compared to 219 man-days lost during the previous 6-month period.

The increase resulted from a large number of areawide strikes associated with negotiations of new area labor agreements and from

absences at Cape Kennedy by building tradesmen who participated in demonstrations at a non-government location.

A single strike by a industrial support contractor at Cape Kennedy accounted for 3,078 of the 4,700 man-days lost on industrial contracts at all Centers. There were no man-days lost during the second half of 1967.

### **Relationships with Other Government Agencies**

NASA continued to maintain close working relationships with other government agencies. While the nature of this Agency's programs kept it in particularly close contact with the Department of Defense, it also maintained cooperative activity and program coordination with the Department of Transportation (including the Federal Aviation Administration), the Department of Commerce and its Environmental Science Services Administration, the Department of Housing and Urban Development, the Atomic Energy Commission, the Department of Agriculture, and the Department of Interior.

The more significant activities between NASA and the Department of Defense were being coordinated through the Aeronautics and Astronautics Coordinating Board and its six specialized panels. In one action, the Manned Space Flight Panel dissolved the National Space Station Planning Sub-Panel and absorbed the functions of the Sub-Panel.

The Board completed a comprehensive review of the proposed NASA and DOD FY 1969 facilities construction programs as outlined in the President's budget. Two proposed DOD facilities duplicated existing or authorized NASA test facilities, but the duplication was considered warranted. In addition, a number of DOD facilities for local technical and institutional support had varying degrees of duplication relative to existing NASA facilities at other sites. This duplication, however, was considered acceptable to support local needs.

The Aeronautics Panel began a review of large ground test facilities necessary to carry out the major new aeronautical programs that might be started in the next 10 to 15 years. These facilities are to be compared with present facilities to determine requirements for additional facilities.

The Launch Vehicle Panel began several studies to explore areas wherein existing launch vehicles may not meet the future needs of both agencies. The Unmanned Spacecraft Panel made a survey of DOD and NASA coordination and information exchange mechanisms in the navigation satellite area. In addition, the two Agencies approved a new joint policy statement concerning criteria related to the applicability of biological in-flight experiments to manned space flight programs.

## PERSONNEL, MANAGEMENT, PROCUREMENT, SUPPORT FUNCTIONS 165

There were significant changes in the AACB membership. Dr. Homer Newell, NASA Associate Administrator, replaced Dr. Robert Seamans as the NASA Co-Chairman; Gen. Jacob Smart replaced Adm. Walter Boone as a NASA Member-at-Large; and Dr. George Mueller replaced Dr. Newell as a NASA Member-at-Large. Mr. Charles Mathews replaced Mr. Edgar Cortright as Chairman of the Manned Space Flight Panel, and Mr. Oran Nicks replaced Mr. Cortright as Chairman of the Unmanned Spacecraft Panel. The Department of Transportation's Assistant Secretary for Research and Technology was included as an observer of the activities of the AACB.

The impact of DOD and NASA funding patterns on universities was examined to find means of more stable university support.

The Board reviewed the instrumentation aircraft and ship requirements in support of the Apollo Program and programs of DOD. It also reviewed the manned space flight network performance during recent Apollo missions. Specialized briefings on NASA and DOD programs covered such items as the Surveyor Program, the Apollo Program, the DODGE satellite, and manned space flight safety co-ordination between the two Agencies.

The number of military personnel detailed to NASA from the DOD remained about the same. As of June 30, approximately 320 military personnel were assigned to NASA. In addition, approximately 12 NASA civilian employees were assigned to other government agencies.

Numerous specialized briefings were presented by NASA for the benefit of other government agencies, or by these agencies for the benefit of NASA. One special briefing, on the technical content of NASA's program, was presented to the Commander, Air Force Systems Command, and to about 50 Air Force key management officials. In addition, NASA briefed the Chief of Naval Operations and the Commandant of the Marine Corps on its current aeronautical and space programs. This briefing resulted in a presentation by the Naval Air Systems Command on its plans and programs for aeronautical research.

Senior FAA, Air Force, and NASA officials met to discuss some of the questions involved in reimbursement for testing of the supersonic transport. Other items considered were the competence of DOD and NASA to assist federal, state, and municipal agencies in urban transportation problems, particularly those in the Northeast corridor.

Representatives of the Department of Housing and Urban Development discussed ways in which NASA's competence could be used to assist in research activities covering housing, community development, utilities, transportation, power, water supply, and other urban problems. The Bureau of Reclamation, Department of Interior, discussed

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prospective areas of cooperative research. One possibility is the application of NASA technology to cloud-seeding.

Based upon joint studies conducted by the Air Force Eastern Test Range and the NASA Kennedy Space Center, the decision was made to consolidate photographic support services at the two installations under a single Air Force prime contract.

NASA and HEW agreed to review proposals for the use of the ATS satellite for demonstrations involving health, education, and community services. Such proposals are to be reviewed by HEW and consideration is to be given to the desirability of funding by HEW.

A joint project involving the Department of Interior, the Naval Research Laboratory, and NASA will explore the use of underseas environment to obtain physiological and psychological data on long-duration space flight. NASA and the Department of Agriculture discussed the possibility of Agriculture's use of the computer facilities of the Mississippi Test Facility and other computer facilities which may become available for use.

The Army indicated an increased interest in vertical take-off and landing aircraft. NASA has studied two specific aircraft proposals, the FX and the VFAX sponsored by the Air Force and the Navy, respectively. A progress report on these studies was made to DOD and NASA personnel at the Langley Research Center.

A revised NASA-Navy agreement concerning procedures for NASA reimbursement to the Navy for assistance in manned space flight recovery operations was approved and signed by both agencies. The Air Force-NASA agreement for the joint investigation of aircraft accidents was signed by the NASA and Air Force officials and became effective March, 1968.

Finally, NASA officials met with officials of the U.S. Geological Survey to discuss earth resources survey programs and the role aircraft and spacecraft should have in obtaining the desired data.

### Safety

In two specific areas of effort, NASA sought to cope with certain problems that, if solved, will have both economy and safety benefits. One relates to the shipment and care of parts, components, and subsystems; the other concerns transport aircraft.

#### **The Zero-Damages-on-Delivery Program**

During the period, NASA took steps to make sure that all critical, delicate, and costly components are properly identified and receive special handling throughout their life cycle. Much of this type of equipment falls in the electronic category which mainly travels as an unobtrusive "black box" in airline transportation.

Extensive negotiations were completed with the major airlines to adopt a program of special care for handling and transporting research and development cargoes. Such added protection is to be maintained throughout the production cycle, in the commercial transportation system, and by the receivers of these items. A NASA Blue Label was developed and is to be used to identify these items at all levels of operation.

This program was resulting in conservation of productive time and a greater reliability of sub-systems and assemblies. In effect, it also contributes to potential savings in engineering, manufacturing, and logistical manpower; to a higher degree of reliability; and to an additional margin of safety.

#### **NASA Transport Aircraft**

NASA was consistently working to improve the operation of its transport aircraft program to achieve maximum effectiveness through safety, proficiency, and standardization. The Administrative Aircraft Standardization Office (AASO), located at Langley Research Center (but reporting directly to Headquarters), developed an Aircraft Operations Manual (NHB 6540.2) which places safety as a primary factor.

The AASO, in its normal operation, performs continuous checks on the aircraft, its equipment, and pilot proficiency. Standardized operations, maintenance procedures, and inspections systems are based on policies prescribed by NASA general management and further developed or managed functionally by the Director, Transportation and Logistics Division. Training and flight safety programs for aircrews assure compliance with FAA operation and maintenance standards.

Quality assurance embraces all events for the start of a maintenance operation to its completion. It is thus the basis for making sure that the aircraft are maintained in accordance with the highest possible standards to further enhance safety-of-flight.

## **Appendix A**

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### **Congressional Committees on Aeronautics and Space**

(January 1-June 30, 1968)

#### **Senate Committee on Aeronautical and Space Sciences**

CLINTON P. ANDERSON, New Mexico, <i>Chairman</i>	SPESSARD L. HOLLAND, Florida
RICHARD B. RUSSELL, Georgia	MARGARET CHASE SMITH, Maine
WARREN G. MAGNUSON, Washington	BOURKE B. HICKENLOOPER, Iowa
STUART SYMINGTON, Missouri	CARL T. CURTIS, Nebraska
JOHN STENNIS, Mississippi	LEN B. JORDAN, Idaho
STEPHEN M. YOUNG, Ohio	EDWARD W. BROOKE, Massachusetts
THOMAS J. DODD, Connecticut	CHARLES H. PERCY, Illinois
HOWARD W. CANNON, Nevada	

#### **House Committee on Science and Astronautics**

GEORGE P. MILLER, California, <i>Chairman</i>	JACK BRINKLEY, Georgia
OLIN E. TEAGUE, Texas	BOB ECKHARDT, Texas
JOSEPH E. KARTH, Minnesota	ROBERT O. TIERNAN, Rhode Island
KEN HECHLER, West Virginia	BERTRAM L. PODELL, New York
EMILIO Q. DADDARIO, Connecticut	JAMES G. FULTON, Pennsylvania
J. EDWARD ROUSH, Indiana	CHARLES A. MOSHER, Ohio
JOHN W. DAVIS, Georgia	RICHARD L. ROUDEBUSH, Indiana
WILLIAM F. RYAN, New York	ALPHONZO BELL, California
THOMAS N. DOWNING, Virginia	THOMAS M. PELLY, Washington
JOE D. WAGGONNER, Jr., Louisiana	DONALD RUMSFELD, Illinois
DON FUQUA, Florida	EDWARD J. GURNEY, Florida
GEORGE E. BROWN, Jr., California	JOHN W. WYDLER, New York
WILLIAM J. GREEN, Pennsylvania	GUY VANDER JAGT, Michigan
EARLE CABELL, Texas	LARRY WINN, Jr., Kansas
	JERRY L. PETTIS, California
	DONALD E. LUKENS, Ohio
	JOHN E. HUNT, New Jersey

## **Appendix B**

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### **National Aeronautics and Space Council**

(January 1-June 30, 1968)

HUBERT H. HUMPHREY, *Chairman*  
*Vice President of the United States*

DEAN RUSK  
*Secretary of State*

CLARK M. CLIFFORD  
*Secretary of Defense*

JAMES E. WEBB, *Administrator*  
*National Aeronautics and Space Administration*

GLENN T. SEABORG, *Chairman*  
*Atomic Energy Commission*

*Executive Secretary*

EDWARD C. WELSH

## Appendix C

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### Principal NASA Officials at Washington Headquarters

(June 30, 1968)

JAMES E. WEBB-----	Administrator
DR. THOMAS O. PAIN-----	Deputy Administrator
DR. HOMER E. NEWELL-----	Associate Administrator
WILLIS H. SHAPLEY-----	Associate Deputy Administrator
HAROLD B. FINGER-----	Associate Administrator for Organization and Management
WILLIAM E. LILLY-----	Assistant Administrator for Administration
PHILIP N. WHITTAKER-----	Assistant Administrator for Industry Affairs
BERNARD MORITZ-----	Assistant Administrator for Special Contracts Negotiation and Review
DR. RICHARD L. LESHER-----	Assistant Administrator for Technology Utilization
FRANCIS B. SMITH-----	Assistant Administrator for University Affairs
DEMARQUIS D. WYATT-----	Assistant Administrator for Program Plans and Analysis
DR. ALFRED J. EGGERS, Jr.-----	Assistant Administrator for Policy
JACOB E. SMART-----	Assistant Administrator for DOD and Interagency Affairs
ADM. CHARLES E. WEAKLEY, USN (Ret.)	Assistant Administrator for Management Development
PAUL G. DEMBLING-----	General Counsel
ARNOLD W. FRUTKIN-----	Assistant Administrator for International Affairs
ROBERT F. ALLNUTT-----	Assistant Administrator for Legislative Affairs
JULIAN SCHEER-----	Assistant Administrator for Public Affairs
DR. GEORGE E. MUELLER-----	Associate Administrator for Manned Space Flight
DR. JOHN E. NAUGLE-----	Associate Administrator for Space Science and Applications
EDMOND C. BUCKLEY-----	Associate Administrator for Tracking and Data Acquisition
DR. MAC C. ADAMS-----	Associate Administrator for Ad- vanced Research and Technology

(Telephone information: 936-7101)

## Appendix D

### Current Official Mailing Addresses for Field Installations

(June 30, 1968)

Installation and telephone number	Official	Address
Ames Research Center; 415-961-1111... Dr. H. Julian Allen, Director...	Moffett Field, Calif. 94035.	
Electronic Research Center; 617-494-2000. Mr. James Elms, Director.....	575 Technology Square, Cambridge, Mass. 02139.	
Flight Research Center; 805-258-3311.. Mr. Paul Bickle, Director.....	Post Office Box 273, Edwards, Calif. 93523.	
Goddard Space Flight Center; 301-982-5042. Dr. John F. Clark, Director.....	Greenbelt, Md. 20771.	
Goddard Institute for Space Studies; 212-UN6-3600. Dr. Robert Jastrow, Director...	2880 Broadway, New York, N.Y. 10025.	
Jet Propulsion Laboratory; 213-354-4321. Dr. W. H. Pickering, Director..	4800 Oak Grove Dr., Pasadena, Calif. 91103.	
John F. Kennedy Space Center; 305-867-7113. Dr. Kurt H. Debus, Director...	Kennedy Space Center, Fla. 32899.	
Langley Research Center; 703-722-4645. Dr. Edgar M. Cortright, Director.	Langley Station, Hampton, Va. 23365.	
Lewis Research Center; 216-433-4000... Dr. Abe Silverstein, Director....	21000 Brookpark Rd., Cleveland, Ohio 44135.	
Manned Spacecraft Center; 713-HU3-3111. Dr. Robert R. Gilruth, Director.	Houston, Tex. 77058.	
George C. Marshall Space Flight Center; 205-877-1000. Dr. Wernher von Braun, Director.	Marshall Space Flight Center, Ala. 35812.	
Michoud Assembly Facility; 504-255-3311. Dr. George N. Constan, Manager.	Post Office Box 29300, New Orleans, La. 71029.	
Mississippi Test Facility; 601-688-2211. Mr. Jackson M. Balch, Manager.	Bay St. Louis, Miss. 39520.	
KSC Western Test Range Operations Division; 805-866-1611. Mr. H. R. Van Goey, Chief....	Post Office Box 425, Lompac, Calif. 93436.	
Plum Brook Station; 419-625-1123.... Mr. Alan D. Johnson, Director.	Sandusky, Ohio 44871.	
Wallops Station; 703-VA4-3411..... Mr. Robert L. Krieger, Director.	Wallops Island, Va. 23337.	

## **Appendix E**

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### **NASA's Historical Advisory Committee**

(June 30, 1968)

*Chairman:* MELVIN KRANZBERG, Western Reserve University and Executive Secretary of the Society for the History of Technology

#### **MEMBERS**

RAYMOND BISPLINGHOFF, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology

JAMES LEA CATE, Department of History, University of Chicago

EARL DeLONG, Dean, School of Government and Public Administration, The American University

A. HUNTER DUPREE, Department of History, University of California (Berkeley)

JOE B. FRANTZ, Department of History, University of Texas

LOUIS MORTON, Department of History, Dartmouth College

ROBERT L. PERRY, Economics Division, The RAND Corporation

*Executive Secretary:* EUGENE M. EMME, NASA Historian

## **Appendix F**

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### **NASA's Inventions and Contributions Board**

(June 30, 1968)

<i>Chairman</i> -----	ERNEST W. BRACKETT
<i>Vice Chairman</i> -----	LEONARD RAWICZ
<i>Director of the Staff</i> -----	FRANCIS W. KEMMETT
<i>Members</i> -----	MELVIN S. DAY C. GUY FERGUSON HARVEY HALL ARTHUR D. HOLZMAN ROBERT E. LITTELL JOHN B. PARKINSON JAMES O. SPRIGGS

## Appendix G

### Patent Waivers Granted and Denied for Separate Inventions Upon Recommendation of the Agency's Inventions and Contributions Board

[January 1-June 30, 1968]

Invention	Petitioner	Action on petition
Frequency Selective Reflector for Radio Waves and Method for Making Same.	Hexcel Corp.	Granted.
Wide Field Microscope.	Farrand Optical Co., Inc.	Do.
Anomalous Count Prevention for Shift Counters.	Radio Corp. of America	Do.
A Decomposition Vessel and a Process Enabling Residence Time Without Contamination.	Bedrich Bernas (employee of National Academy of Sciences).	Do.
Gas Turbine Combustion Apparatus.	Curtiss-Wright Corp.	Denied.
Improved Gas Ring Laser.	Massachusetts Institute of Technology.	Granted.
Dual-Mode Range Acquisition System.	Motorola, Inc.	Do.
Scheme to Maintain Voltage-Time Integral Balance Between Half Cycles in a Current Feedback Converter.	Honeywell Inc.	Denied.
Solder Reflowing Device.	North American Rockwell Corp.	Granted.
Wafer Type Fuel Cell.	United Aircraft Corp.	Do.
Thermochromic Materials.	General Precision Systems, Inc.	Do.
Segmentally Constructed Combustor Liner.	Curtiss-Wright Corp.	Denied.
Compositions for High Modulus Glass Fibers.	United Aircraft Corp.	Granted.
Auxiliary Signal Electrode.	General Electric Co.	Do.
Oxygen Signal Electrode.	do.	Do.
Electromagnetic Liquid Pump.	Hughes Aircraft Co.	Do.
Solid State Triode.	California Institute of Technology.	Do.
Low Input Voltage Converter.	Honeywell, Inc.	Denied.
Scan Conversion Synchronization Control Arrangement.	Hughes Aircraft Co.	Do.
Procedure for Fabricating Controlled Porosity Metals.	do.	Granted.
Time Delay Measurement.	Motorola, Inc.	Do.
Solar Cell Protective Means.	TRW, Inc.	Denied.
Solid Oxygen Candle Assembly, Aerospace.	Garrett Corp.	Do.
High Temperature Thermocouple.	North American Rockwell Corp.	Granted.
Tubular Connectors for Pressure Suit.	International Latex Corp.	Do.
Flexible Overlapping Connection Method for Solar Cells.	TRW, Inc.	Do.
Solid Oxygen Supply Automatic Control Systems.	Garrett Corp.	Do.
Formation of Optical Waveguides by Irradiation of Dielectric with Heavy Charged Particles.	Wheeler Laboratories, Inc.	Do.
Phase Modulated Electric Suspension for Electric Vacuum Gyro.	General Motors Corp.	Do.
Automatic Frequency Control System.	International Telephone & Telegraph.	Denied.
Planar Antenna Array.	Hughes Aircraft Co.	Granted.

Invention	Petitioner	Action on petition
Cryogenic Heat Transfer Control System.....	General Electric Co.....	Granted.
Fuel Cell Purge Controller.....	Allis-Chalmers Manufacturing Co.	Do.
Fuel Cell Temperature Control.....	do.....	Do.
Control Power Supply.....	do.....	Do.
Catalyst for Hydrazine Decomposition.....	Shell Development Co.....	Do.
Impact Landing System.....	North American Rockwell Corp.	Do.
Hydrogen Leak Detection Device.....	do.....	Denied.
Methods and Apparatus for Continuous Dialysis.....	Regents of the University of California.	Do.
Integrated Circuit Thin Film Magnetometer.....	Lockheed Missiles and Space Co.	Granted.
High Permittivity Low-Loss Dielectric System.....	General Electric Co.....	Do.
Method of Obtaining Low Dielectric Losses in High Dielectric Constant Liquids.	do.....	Do.
Remote Local Oscillator Frequency Multiplier.....	Scientific-Atlanta Inc.....	Do.
Coldplate Fabrication Process.....	McDonnell Douglas Corp.....	Denied.
High Temperature Alloy.....	General Electric Co.....	Granted.
Inorganic Ion-Exchange Membranes and the Preparation Thereof.	IIT Research Institute.....	Denied.

## Appendix H

### Patent Waivers Granted and Denied for All Inventions Made during Performance of Contract Upon Recommendation of the Agency's Inventions and Contributions Board

(January 1-June 30, 1968)

Contract description <sup>1</sup>	Petitioner	Action on petition
Research and Development of a Variable Deflection Thrustor for Helicopter Application.	Honeywell, Inc.	Granted.
Fabricate, Assemble, and Test Computer Equipment in the Nature of Flight Data Storage Subsystems and Associated Operational Support Equipment.	Texas Instruments, Inc.	Do.
Development of Magnetic Logic Batch Fabrication Techniques.	Ampex Corp.	Do.
Program for Research, Development, and Application of Non-Flammable Carboxyl Nitroso Polymer.	Thiokol Chemical Corp.	Denied.
A Quiet Engine Definition Program.	General Motors Corp.	Do.
Study of Synthesis of Glycerol.	Esso Research and Engineering Co.	Granted.
Develop and Fabricate Motor/Cable Drum Assembly.	United Shoe Machinery Corp.	Do.
Fabricate Flight Model Radiometer System.	Sanders Associates, Inc./Geospace Electronics Div.	Do.
Investigation of Single Crystal Ferrite Thin Films.	North American Rockwell Corp./ Autometrics Div.	Denied.
Development of Prototype Oculometer.	Honeywell Inc.	Do.
Development of High Energy Density Primary Batteries.	do.	Granted.
Study to Determine Design Concept of Instrumentation Record/Reproduce System for STADAN.	Ampex Corp.	Do.
Infrared Interometer Spectrometer.	Texas Instruments Inc.	Do.
Investigate the Thrust Vector of an Electron Bombardment Ion Engine.	Hughes Aircraft Co.	Do.
Investigation of Electro-Optical Modulator Array for Use in Holographic Storage Device.	Carson Laboratories, Inc.	Do.
Development of Quality Standards Inspection Criteria and Reliability Screening Techniques for Large Scale Integrated Circuits.	Texas Instruments, Inc.	Do.
To build a Laser Ranging Device for Measuring the Vibrations in Distance From the Moon to the Earth.	Hughes Aircraft Co.	Do.
R & D of an Electronically-Tuned Optical Filter.	Radio Corp. of America.	Do.
Feasibility and Design Study of Radar System for Detecting Micrometeoroids.	Texas Instruments, Inc.	Do.
Development and Triaxial Fabrics for Space Applications.	General Electric Co.	Do.
R & D of Electrochromatic Storage Display Device.	Radio Corp. of America.	Do.
Investigation of Refractory Dielectrics for Integrated Circuits.	IBM Corp.	Do.
Study of Multiple Reserve Electrochemical Power Source.	North American Rockwell Corp./Atomics International Div.	Do.
Nonflammable Flight Paper.	W. R. Grace & Co.	Do.

Contract description <sup>1</sup>	Petitioner	Action on petition
Development of Auxiliary Power Supply for the Apollo Lunar Module.	TRW Inc., TRW Systems Group.	Granted.
Study of Parameters To Build a Combined Acquisition & Tracking System for Locating Objects in Space.	Texas Instruments, Inc.	Do.

<sup>1</sup> Waiver before execution of contract.

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#### Petitions deferred

Dow Chemical Company (BW-943)	Honeywell Incorporated (BW-928)
Hughes Aircraft Company (BW-940)	Hughes Aircraft Company (BW-934)
Dow Chemical Company (BW-897)	Carco Electronics (BW-881)
Bell Helicopter Company (BW-910)	

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## Appendix I

### Scientific and Technical Contributions Recognized by the Agency's Inventions and Contributions Board

(January 1-June 30, 1968)

#### Awards Granted Under Provisions of Section 306 of the Space Act of 1968

Contribution	Inventor(s)	Employer
Support structure for irradiated elements.	Anthony J. Nasuti.....	Computer Control Co., Inc.
Rock drill for recovering samples.	Allen G. Ford.....	Jet Propulsion Laboratory.
Choke for broadband antenna.	Otis L. Bishop, Conway A. Bolt, Jr.	Westinghouse Electric Corp.
High pressure air valve.	Benjamin T. Howland.....	North American Rockwell Corp.
Dual pressure regulator.	Karl F. Jackson.....	The Garrett Corp.
Rotating mandrel for assembly of inflatable devices.	Sigvard J. Stenlund, Alfred J. Wendt, John A. MacFadden.	G. T. Schjeldahl Co.
Method and apparatus for ejection of an instrument cover.	Bennie R. Wells, Charles W. Rowland.	Marshall Space Flight Center. Chrysler Corp.
Variable frequency nuclear magnetic resonance (NMR) spectrometer.	Dimitter I. Tchernev, Harry G. Vorkink, John E. Guisinger.	Jet Propulsion Laboratory.
Protection for energy conversion systems.	Edward R. Pasciutti, Michael W. Talbot.	Goddard Space Flight Center. Airtronics, Inc.
Stretcher.	Francis X. Lothschuetz.....	Mason-Rust Co.
Dual latching solenoid valve.	William C. McNutt, Hugh G. Odell.	The Garrett Corp.
Pressure-telemetry transducer and fabrication process therefor.	Royal G. Harrison, Jr.....	Jet Propulsion Laboratory.
Stabilized zinc oxide coating compositions.	Gene A. Zerlaut, Daniel W. Gates, William F. Carroll.	Illinois Institute of Technology Research Institute.
Reflectometer for receiver input system.	Charles T. Stelzried.....	Jet Propulsion Laboratory.
Photoelastic pure fluid flow stand.	W. W. Scott, Jerry A. Peoples.....	Brown Engineering Co., Marshall Space Flight Center.
Solenoid construction.	Rudolph Rust, Ronald M. Noble..	Jet Propulsion Laboratory.
Indexing microwave switch.	David L. Nixon, Frank E. McCrea.	Do.
Current steering switch.	Lawrence J. Zottarelli.....	Do.
Device for preventing high voltage arcing in electron beam welding.	Karl C. Hanchey, James C. Mahan, James S. Kubik.	Marshall Space Flight Center. Hayes International Corp.
Monopulse tracking system.	John P. Shelton, Jr.....	Radiation Systems, Inc.

## Appendix J

### Awards Granted NASA Employees Under Provisions of the Incentive Awards Act of 1954

(January 1-June 30, 1968)

<i>Contribution</i>	<i>Inventor(s)</i>
<b>ELECTRONICS RESEARCH CENTER:</b>	
Gunn-type solid-state devices-----	Wilhelm Rindner and Harold Roth.
Refractory dielectric semiconductors-----	Robert L. Trent.
<b>GODDARD SPACE FLIGHT CENTER:</b>	
Monopulse system with an electronic scanner.	Armando D. Elia and Richard F. Schmidt.
Tape recorder-----	Paul W. Uber.
Electrochemical goulometer-----	Eugene R. Stroup.
Controlled etching of printed circuits-----	John B. Schutt and Stanley P. Kovell.
Fire resistant coating composition-----	John B. Schutt and John W. Stuart.
Time division multiplex system-----	Walter K. Allen.
Logarithmic converter-----	David H. Schaefer.
Bacteriostatic conformal coating and methods of application.	Francis N. LeDoux and Charles Bland.
Method for generating ultra-precise angles.	Robert L. Appler.
A balance torquemeter-----	Joseph C. Boyle.
Dust particle injector for hypervelocity accelerators.	Otto E. Berg.
Mechanical actuator-----	John C. Johnson, Jr., Jesse M. Madey, Xopher W. Moyer, and Dennis K. McCarthy.
Nickel-cadmium battery reconditioner-----	Floyd E. Ford and Kenneth O. Sizemore.
Non-magnetic battery case-----	Thomas Hennigan.
Ampere-hour integrator-----	John Paulkovich.
Circuit array providing minimal induced magnetic fields.	Luther W. Slifer, Jr.
Traffic control system and method-----	Charles R. Laughlin, Roger Hollenbaugh, and Walter Allen.
Position location system and method-----	Charles R. Laughlin and Roger Hollenbaugh.
Cartwheel satellite synchronization system.	James A. Gatlin.
Variable digital processor-----	Robert J. Lesniewski.
Analog to digital converter-----	Henry Doong.

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**Awards Granted NASA Employees Under Provisions of the Incentive Awards Act of 1954—Continued**

<i>Contribution</i>	<i>Inventor(s)</i>
<b>JOHN F. KENNEDY SPACE CENTER:</b>	
Emergency escape system-----	Charles R. Billings, Robert A. McDaris, John T. McGough, Paul F. Neal, and James C. Sweat.
Constant current device-----	Harold F. Barnes.
Parasitic probe antenna-----	Herbert E. Cribb.
Parasitic probe antenna-----	Do.
Phonocardiogram (PKG) simulator-----	John M. Keefer.
Validation device for spacecraft check-out equipment.	Herbert E. Cribb.
Weld preparation machine-----	Elvis D. Wallace.
<b>LANGLEY RESEARCH CENTER:</b>	
Vibrating structure displacement measuring instrument.	Bruce Flagge.
Cooperative doppler radar system-----	James H. Schrader.
Aeroelastic structures-----	Francis M. Rogallo and Rodger L. Naeseth.
Brake control system-----	Sidney A. Batterson.
Surface contour surveying system-----	Colossie N. Batts, Robert W. Hess, and Frederick W. Gibson.
Arbitrarily shaped model survey system..	Eugene C. Naumann and Bruce Flagge.
Variable width pulse integrator-----	Arthur L. Newcomb, Jr.
Integrated time-shared instrumentation display.	Jack J. Hatfield.
Flow field simulation-----	Robert A. Jones and James L. Hunt.
Miniature vibration isolator-----	David H. Butler and Wilbert C. Falk.
Instrument for measuring the dynamic behavior of liquids.	David G. Stephens and Clemens A. Powell, Jr.
Process for applying black coating to metals.	Beverley W. Lewis and Donald J. Progar.
Supersonic aircraft-----	Augustine W. Robins, Roy V. Harris, Jr., Harry W. Carlson, Francis E. McLean, and Wilbur D. Middleton.
Self-repeating plasma accelerator-----	Alexander P. Sabol.
Ullage compensator-----	Otis J. Parker.
Thermal protection ablation spray-----	William M. Haraway, Jr. and Robert T. Magee.
Hydraulic grip-----	Fred F. Eichenbrenner and Walter Illg.
Translating horizontal tail-----	Morris L. Spearman.
Variable area flexible wings-----	Francis M. Rogallo.

**Awards Granted NASA Employees Under Provisions of the Incentive  
Awards Act of 1954—Continued**

<i>Contribution</i>	<i>Inventor(s)</i>
<b>LEWIS RESEARCH CENTER:</b>	
Thermionic converter with current augmented by self-induced magnetic field.	Alex Vary.
Triode thermionic energy converter	Do.
Automatic recording McLeod gauge	Paul A. Faeth.
Rolling element bearings	Dean C. Glenn.
Heat flux measuring device	Norman T. Musial.
<b>MANNED SPACECRAFT CENTER:</b>	
Spacecraft radiator cover	Joseph A. Chandler.
Coupling device	Elton M. Tucker.
<b>GEORGE C. MARSHALL SPACE FLIGHT CENTER:</b>	
Cross-linking of unsaturated polymers with silicon hydrides.	William J. Patterson.
Passive optical wind and turbulence	Fritz R. Krause.
Pulse rise time and amplitude detector	Murrell D. Slayden and Hugh W. Staley.
High pressure gas filter system	John A. Hauser.
Mechanical simulator	Dan H. Dane.
Burst diaphragm flow initiator	John W. Davis and Olen E. Hill.
Ceramic insulation for radiant heating environments and method of preparing the same.	Vaughn F. Seitzinger.
Azimuth laying system	Herman E. Thomason and Carl H. Mandel.
Gravimeter	Orlo K. Hudson.
Multiway vortex valve system	Jerry A. Peoples.
Pulse width inverter	James R. Currie and Harry Reid, Jr.
Method and apparatus for securing to a spacecraft.	Alfred P. Warren and William R. Lauderdale.
Weld control system using thermocouple wire.	William M. McCampbell.
Serpentuator	Hans F. Wuenscher.
Positive DC to negative DC converter	Eugene H. Berry and Frank J. Nola.
Apparatus for the determination of the existence or non-existence of a bonding between two members.	Wayman N. Clotfelter and Benjamin F. Bankston.
Synthesis of siloxane-containing epoxy polymers.	William J. Patterson.
Power system with heat pipe liquid coolant lines.	Ambrose W. Byrd.

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**Incentive Awards Act Awards by Centers**

(January 1-June 30, 1968)

Center	Number of inventions	Number of awardees	Number of persons	Amount of awards
Ames Research Center-----				
Electronics Research Center-----	2	3	3	\$200
Flight Research Center-----				
Goddard Space Flight Center-----	21	32	29	6, 850
John F. Kennedy Space Flight Center-----	7	11	9	1, 950
Langley Research Center-----	19	33	31	6, 300
Lewis Research Center-----	5	5	4	600
Manned Spacecraft Center-----	2	2	2	400
George C. Marshall Space Flight Center-----	18	25	24	5, 350
Wallops Station-----				
Total-----	74	111	102	21, 650

## **Appendix K**

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### **NASA's Contract Adjustment Board**

(June 30, 1968)

<i>Chairman</i> -----	E. M. SHAFER.
<i>Members</i> -----	ERNEST W. BRACKETT. MELVYN SAVAGE. WILLIAM E. STUCKMEYER. FRANCIS J. SULLIVAN DANIEL M. ARONS.
<i>Counsel to Board</i> -----	

## **Appendix L**

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### **NASA's Board of Contract Appeals**

(June 30, 1968)

<i>Chairman</i> -----	ERNEST W. BRACKETT.
<i>Vice-Chairman</i> -----	MATTHEW J. McCARTIN.
<i>Members</i> -----	Daniel M. Arons. John B. Farmakides. Donald W. Frenzen. Wolf Haber. (Mrs.) Evelyn Kirby.
<i>Recorder</i> -----	

## Appendix M

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### Educational Publications and Motion Pictures

(June 30, 1968)

NASA released these new educational publications during the first six months of 1968. They are available to the public without charge from the Special Events Division, FGE-1, National Aeronautics and Space Administration, Washington, D.C. 20546. Other publications are listed in a folder supplied from the same address.

#### Booklets

Address by Dr. Roger W. Heyns, Chancellor, University of California, Berkeley, at NASA's Honors Awards Ceremony, Washington, D.C., October 24, 1967. (*Speaking of Space and Aeronautics*, Vol. iv, No. 3, 7 pp.)

Address by Dr. Robert C. Seamans, Jr., Former Deputy Administrator, National Aeronautics and Space Administration, on the "Aeronautical Aspects of NASA's Program", before the Aero Club of Washington (D.C.), October 24, 1967. (*Speaking of Space and Aeronautics*, Vol. iv, No. 4, 17 pp.)

*Fifty Years of Aeronautical Research*.—A brief illustrated history prepared by NASA's Langley Research Center, 71 pp.

#### Space Resources for the High School

A new series of resource guides on the Nation's aeronautics and space programs for secondary school teachers. First published—*Industrial Arts Resource Units*—prepared for NASA by a committee of industrial arts educators under the direction of John L. Feirer, Western Michigan University, in connection with a conference conducted by the University of Florida, with the cooperation of the Florida State Department of Education and the John F. Kennedy Space Center. Illus. 178 pp.

#### NASA Facts (Organization Series)

A series covering the work of each NASA center.

*Goddard Space Flight Center*.—Describes the center at Greenbelt, Md. responsible for developing unmanned orbiting scientific satellites, sounding rocket experiments, and NASA's worldwide network of tracking stations serving manned and unmanned space missions. 4 pp.

*Wallop Station*.—Details the research at this Virginia station, about 40 miles from Salisbury, Md., directed primarily toward gathering information about earth's atmosphere and its near-space environment. 4 pp.

*Marshall Space Flight Center*.—A description of the center at Huntsville, Ala., where large launch vehicles such as Saturn V, and spacecraft for deep space and near-earth missions, are developed. Here also studies are made of future space exploration projects. 4 pp.

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*Manned Spacecraft Center*.—Describes the center (Houston, Tex.), one of the newest and largest of NASA's research and development facilities, serving as a focal point for the manned space flight program. 4 pp.

*Ames Research Center*.—Notes on the facility at Moffett Field, Calif., which performs basic and applied research in the physical and life sciences to support the Nation's space and aeronautical programs. 4 pp.

### NASA Facts (Science Series)

Series designed for teachers to use in explaining basic science concepts in space exploration.

*Rocket Propulsion*.—A brief description of the power that propels rockets. 4 pp.

*Space Navigation*.—This booklet explains that space navigation is about the same as navigation on earth—"a process of finding out where you are with respect to where you want to be." 8 pp.

*Electric Power Generation in Space*.—As on earth, electricity is one of the most useful forms of energy in space. Its many uses are explained in these pages. 20 pp.

*Food for Space Flight*.—The special procedures necessary for preparing, packaging, and storing food for U.S. manned space flights are outlined in this publication. Illustrated in color. 8 pp.

*Journey to the Moon*.—The lunar voyage described in simplified terms from launch to recovery. A fold-out in full color for wall display.

### Bibliographies

*Aerospace Bibliography*, 4th ed.—A current listing of aerospace books, periodicals, audiovisual aids, and other resources keyed to show grade levels. Compiled for NASA by the National Aerospace Education Council. 63 pp.

### Motion Pictures\*

Also released was the following motion picture which may be borrowed, without charge other than return mailing and insurance costs, from Media Development Division, Code FAD-2, National Aeronautics and Space Administration, Washington, D.C. 20546, or from any NASA center. (Other films are listed in a brochure supplied from the same addresses.)

*X-ray Spectroscopy—The Inside Story*.—1968, color, 25½ min., 16mm. Dr. Robert J. Liefeld, Professor of Physics at New Mexico State University, explains how X-rays are generated and how an X-ray spectrometer disperses them in a spectrum. Professor Liefeld shows how specially-grown crystals are produced and used in a two-crystal vacuum X-ray spectrometer to diffuse an X-ray beam, isolate a single wavelength, and scan a spectrum and record its characteristics.

\*From January through June 1968 NASA received 1,681 requests from teachers, professional organizations, and the general public for motion pictures, and supplied 47,457 feet of film to producers of educational and documentary motion pictures and telecasts. Motion picture film catalogued and stored in the Agency's depository reached 8,396,144 feet.

## Appendix N

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### Technical Publications

(January 1–June 30, 1968)

The following special publications, among those issued during the report period by NASA's Scientific and Technical Information Division, are sold by the Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, D.C. 20402, or by the Clearinghouse for Federal Scientific and Technical Information (CFSTI), Springfield, Va. 22151, at the prices listed.

*Scientific Satellites* (by William R. Corliss).—This is a comprehensive study of unmanned scientific satellites by an engineer noted for his skill in technical reporting. It covers the period from 1957, when a Russian satellite first beeped its greetings, through 1966. One major section deals with missions and spacecraft, and another with scientific instruments. Designs, experiments, capabilities, and orbits are recorded. A general bibliography and an appendix giving specifications of scientific satellites enhance the value of the work to students. NASA SP-133. 1968. 822 pp. GPO, \$3.00.

*Gemini Summary Conference*.—Participants summarize the major results of the 10 manned flights of the Gemini Program in this Special Publication. It contains 21 technical papers presented at a Gemini Summary Conference on February 1 and 2, 1967, at the NASA Manned Spacecraft Center in Houston, Tex.; an introduction by George E. Mueller, Associate Administrator for Manned Space Flight, and 44 color photographs taken by the astronauts.

Five papers describe the rendezvous, docking, and tethering of spacecraft and a target vehicle; five describe extravehicular activities, and five review the operational support of the missions. Additional papers deal with onboard experiments, including synoptic terrain and weather photography; compare simulated and actual flight experiences, and relate results of the Gemini flights to the Apollo lunar-landing program. NASA SP-138. 1967. 345 pp. GPO, \$2.75.

*Mariner-Mars 1964: Final Project Report*.—This is a technical history of the first man-made probe to travel to Mars, from the inception of the project in 1962 until two-way communication with the spacecraft was interrupted October 1, 1965. Prepared by Jet Propulsion Laboratory, the report describes the trajectory, the vehicle, testing operations, the flight, the tracking and data acquisition, and the engineering and scientific results. An appendix shows the project organization, and a bibliography lists 101 sources of further information. NASA SP-139. 1968. 346 pp. GPO, \$2.50.

*Third Annual NASA-University Conference on Manual Control*.—This volume contains 34 papers presented at the University of Southern California, March 1 to 3, 1967. Discrete and decision processes in human actions are emphasized. The topics discussed included display systems, function models, computer processing of manual control records, psychological monitoring, advanced modeling techniques, and applications of manual control theory to problems involving

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simulators and both aircraft and spacecraft. NASA SP-144. 1968. 459 pp. CFSTI, \$3.00.

*Sonic Boom Research* (A. R. Seebass, Ed.).—Possible means of reducing sonic boom overpressures, and the adequacy of current research, were discussed at NASA headquarters April 12, 1967. This volume contains five invited papers presented at that conference on basic theory, the effects of airplane operations and the atmosphere on sonic booms, and the effects of some booms on people and structures. A problem that has threatened to restrict commercial supersonic transport operations is further clarified in a preface by the editor and contributed remarks of participants from university and other laboratories. NASA SP-147. 1968. 118 pp. GPO, 50 cents.

*Summary of Gemini Extravehicular Activity* (Reginald M. Machell, Ed.)—The NASA Manned Spacecraft Center staff reviews the lessons of 12 hours and 25 minutes of extravehicular activity in this report, which includes recommendations regarding restraints, space suits, training, and other requirements. The developments of life support systems, umbilical and tether combinations, and maneuvering equipment is recalled. So, too, are the training methods, and operational and medical aspects of the capabilities that men demonstrated during the Gemini flights. NASA SP-149. 1968. 336 pp. CFSTI, \$3.00.

*Aerospace Electronic Systems Technology: A Briefing for Industry*.—NASA spokesmen explained current and upcoming mission goals and demands upon aerospace technology at a briefing for industry sponsored by the Electronics Industries Association, May 3 and 4, 1967, at the Massachusetts Institute of Technology. The proceedings recorded in this volume delineate the role of the Electronics Research Center in Cambridge, Mass., and include discussions of the state of Earth orbital technology, lunar and planetary technology, and avionics. NASA SP-154. 1968. 290 pp. GPO, \$1.25.

*Significant Achievements in Space Science 1966*.—This volume describes the many achievements in 1966 that were both significant steps toward the goals of scientific research and exciting news for lay readers. In it, authorities on space astronomy, space bioscience, ionospheres and radio physics, particles and fields, and solar physics summarize and relate discoveries and technological advances that promise to be of especial importance in their disciplines. NASA SP-155. 1968. 419 pp. GPO, \$1.50.

*Significant Achievements in Space Applications 1966*.—Satellites supported global programs in communications, meteorology, and geodesy in 1966, and indicated their potential usefulness in navigation, traffic control, agriculture, forestry, transportation, geology, hydrology, oceanography, and geography. Robert H. McQuain of the NASA Office of Space Science and Applications describes the progress made in deriving social and economic benefits from satellites. NASA SP-156. 1968. 91 pp. GPO, 50 cents.

*Recent Advances in Display Media*.—How can computer-generated information best be displayed in advanced aircraft and spacecraft? Fifteen papers given at a symposium sponsored by the Electronics Research Center in Cambridge, Mass., September 19 and 20, 1967, deal with aspects of this art. Thermo-chromic, fluidic, magnetic, electrostatic, laser and other display devices are among those considered. Technology applicable to nonaerospace systems as well as to cockpit displays is reviewed and current challenges to it are considered. NASA SP-159. 1968. 146 pp. GPO, \$1.00.

*Bioregenerative Systems*.—Proceedings of a conference sponsored by the American Institute of Biological Sciences and NASA, at Washington, in November 1966, include papers on the chemosynthetic approach to a closed bioregenera-

tive life-support system, and related matters including the multidisciplinary research program dealing with the organism *Hydrogenomonas*. NASA SP-165. 1968. 153 pp. GPO, \$1.50.

*Surveyor VI, A Preliminary Report*.—Numerical values for physical and chemical properties of the lunar surface were refined and new information on the grain-size distribution became available. All Surveyor program requirements relative to the Apollo landing-site section were completed on the mission reviewed in detail in this volume. Photos and tables enhance the text. NASA SP-166. 1968. 165 pp. CFSTI, \$3.00.

*Protection Against Space Radiation*.—Special sessions of the American Nuclear Society's 13th annual meeting, at San Diego, Calif., in June 1967, dealt with this topic. This volume records the proceedings. NASA SP-169. 1968. 600 pp. CFSTI, \$3.00.

*Tables of Fe I Line Intensities—Vol. I. Temperatures from 1000° to 6500° K; Vol. II. Temperatures Between 6500° and 20000° K* (By William J. Borucki).—Tables of intensities for 2200 atomic lines are presented in tables intended for use in computing the absolute intensity and spectral distribution for Fe I line radiation from optically thin media, determining the temperature of an observed plasma, and indicating a non-Boltzmann distribution of excited electronic states when such conditions exist. NASA SP-3041. 1968. 218 pp. CFSTI, \$3.00.

*Properties of Magnetic Materials for Use in High-Temperature Space Power Systems* (by P. E. Kueser, D. M. Pavlovic, D. H. Lane, J. J. Clark, and M. Spewock).—Test data are given and evaluated for eight magnetic materials found suitable for high-temperature liquid alkali-metal system applications. Each one is discussed with respect to its use in equipment parts operating at two different temperature levels. NASA SP-3043. 1968. 318 pp. GPO, \$2.50.

*Method of Brazing Aluminum to Stainless Steel for High-Stress-Fatigue Applications*.—This report describes a procedure developed for NASA by the Rocketdyne Division of North American Aviation, Inc., to minimize the formation of intermetallic compounds in aluminum-stainless-steel joints for valve assemblies in rocket motors. The author, D. C. Martin, of the Battelle Memorial Institute, believes the procedure also can be followed advantageously in meeting other challenges to materials engineers. NASA SP-5040. 1968. 11 pp. GPO, 15 cents.

*Earthquake Prediction from Laser Surveying*.—This report by R. A. Fowler describes a dual-beam laser system developed by North American Aviation, Inc., subsequent to a Laser Space Communications Systems Study done under contract for NASA. The author discusses its use both to predict earthquakes and to measure the response of structures to earthquake activity. NASA SP-5042. 1968. 32 pp. GPO, 35 cents.

*Teleoperators and Human Augmentation* (by Edwin G. Johnsen and William R. Corliss).—This AEC-NASA Survey describes dexterous, general-purpose, cybernetic machines that now enable men to operate tools in a hostile environment without personally entering it. Such machines are both extending and amplifying men's capabilities in space, the ocean depths, and industrial plants. They are also being adapted to help physically handicapped persons enjoy greater mobility.

Edwin G. Johnsen. Facilities Chief of the Joint AEC-NASA Space Nuclear Propulsion Office, and William R. Corliss, a professional technical writer, produced this generously illustrated study of the status and potentialities of teleoperators. After tracing the evolution of design principles embodied in current machines, they discuss the interfaces between men and these new machines.

Teleoperator technology has germinated and grown independently whenever men have tried to augment their hands, arms, and legs with machines. Most of the several thousand manipulator arms built in recent years have been used in atomic energy installations. Similar machines, the authors argue, can be used now increasingly to free men from dull, routine tasks.

The eight principal subsystems of today's outstanding teleoperators are described in detail, with particular emphasis on actuating, sensing, and terminal devices. NASA SP-5047. 1968. 265 pp. GPO, \$1.00.

*Constructing Inexpensive Automatic Picture-Transmission Ground Stations* (by Charles H. Vermillion).—This report tells how to build a ground station to receive pictures from weather satellites. Such a station can be built from surplus parts costing less than \$500. Local weather services, radio and TV stations, scientists, farm cooperatives, and other interested persons are now receiving cloud-cover pictures several times a day via such stations in all parts of the world. The antenna, FM receiver, and other components are described and the operation of such a ground station is explained. NASA SP-5079. 1968. 62 pp. CFSTI, \$3.00.

*Machining and Grinding of Ultrahigh-Strength Steels and Stainless Steel Alloys* (by C. T. Olofson, J. A. Gurklis, and F. W. Boulger).—NASA SP-5084, 1968. 202 pp. CFSTI, \$3.00.

*Adhesive Bonding of Stainless Steels—Including Precipitation-Hardening Stainless Steels* (by R. E. Keith, M. D. Randall, and D. C. Martin). NASA SP-5085. 1968. 115 pp. CFSTI, \$3.00.

*Shaping of Precipitation-Hardening Stainless Steels by Casting and Powder Metallurgy* (by J. G. Kura, V. D. Barth, and H. O. McIntire).—NASA SP-5086. 1968. 42 pp. CFSTI, \$3.00.

*Welding of Precipitation-Hardening Stainless Steels* (by J. J. Vagi, R. M. Evans, and D. C. Martin).—NASA SP-5087. 1968. 181 pp. CFSTI, \$3.00.

*Deformation Processing of Precipitation-Hardening Stainless Steels* (by D. E. Strohecker, A. F. Gerds, and F. W. Boulger).—NASA SP-5088. 1968. 256 pp. CFSTI, \$3.00.

*Thermal and Mechanical Treatment for Precipitation-Hardening Stainless Steels* (by C. J. Slunder, A. F. Hoenie, and A. M. Hall).—NASA SP-5089. 1968. 193 pp. CFSTI, \$3.00.

*Surface Treatments for Precipitation-Hardening Stainless Steels* (by A. M. Hall).—NASA SP-5090. 1968. 58 pp. CFSTI, \$3.00.

*Introduction to the Derivation of Mission Requirements Profiles for System Elements*.—From the mission requirements profile for an overall system, requirement profiles for subsystems can be derived by identifying the relating parameters and resolving their influence numerically. This document describes a 10-step process. Appendices illustrate its use to derive requirement profiles for six subsystems of spacecraft. NASA SP-6503. 1968. 91 pp. CFSTI, \$3.00.

*Introduction to the Assurance of Human Performance in Space Systems*.—For project engineering and management personnel, this is a guide to methods of detecting and eliminating human-induced failures. Design features, procedures, and work situations are considered. NASA SP-6506. 1968. 42 pp. CFSTI, \$3.00.

*An Annotated Bibliography of Computer-Aided Circuit Analysis and Design* (by Charles W. Meissner, Jr.).—This document presents an annotated bibliography of computer-aided circuit analysis, beginning with 1956 when the first serious attempts were made to use the computer as an aid to the analysis and design of electronic circuits, up to the middle of 1966. Emphasis has been placed on pro-

grams and their application rather than on related areas. NASA SP-7023. 1968. 41 pp. CFSTI, \$3.00.

*Management: A Continuing Literature Survey With Indexes.*—This is a selection of annotated references to unclassified reports and journal articles entering the NASA information system from 1962 through 1967. NASA SP-7500. 1968. 55 pp. CFSTI, \$3.00.

## Appendix O

### Major NASA Launches

(January 1–June 30, 1968)

Name, date launched, mission	Vehicle	Site <sup>1</sup>	Results
Surveyor VII, Jan. 7..... NASA's 7th and last spacecraft designed to softland on the moon and transmit TV pictures of its landing site. Would also analyze the lunar soil.	Atlas-Centaur .. ETR ..		Spacecraft landed on the rugged, rock-strewn, ejecta blanket just north of the Tycho crater. It transmitted over 21,000 TV pictures, photographed the earth, and surveyed the stars. Surveyor also sampled the moon's surface and manipulated the lunar material. Laser beams from the earth were detected by the spacecraft's television camera.
GEOSS-II (Explorer XXXVI), Jan. 11. Geodetic satellite designed to help develop a more precise model of the earth's gravitational field and add to scientists' knowledge of the size and shape of the earth.	Thor-Delta..... WTR ..		Satellite supported the National Geodetic Satellite Program. Its observations were transmitted to about 200 stations around the world. (Apogee 977 miles; perigee 670 miles.)
Apollo 5 (AS-204), Jan. 22..... Flight was to verify operation of the Lunar Module descent and ascent propulsion systems including restart; evaluate lunar module staging; and evaluate launch vehicle performance.	Saturn IB..... ETR ..		Launched into earth orbit to carry out a highly successful mission. Ascent and descent propulsion systems performed as designed. Ability to abort a lunar landing and return to orbit were demonstrated.
O GO-V, Mar. 4..... The 5th Orbiting Geophysical Observatory carrying 24 scientific experiments to study the earth's space environment and its relationship to the sun during a period of maximum solar activity. Primary mission is to carry out a comprehensive study of particles and fields in space.	Atlas-Agena..... ETR ..		Spacecraft placed into a highly elliptical earth orbit—apogee 92,000 miles and perigee 186 miles. All experiments were operating, including those provided by England and France.
Apollo 6 (AS-502), Apr. 4..... To qualify the launch vehicle for manned flight.	Saturn V..... ETR ..		Launched into an earth orbit, although 2 of the 5 2d-stage engines stopped prematurely. 3d-stage engine failed to restart, but the Command Module achieved its intended apogee, re-entered the earth's atmosphere, and was recovered.
Reentry F, Apr. 27..... Reentry turbulent heating experiment to measure heat transfer on a slender cone at hypersonic speeds (20,000 fps) for comparison with ground studies.	Scout..... WI ..		Reentered the atmosphere at 19,750 feet per second to impact within 5 miles of its aiming point near Bermuda. Transitional and fully developed turbulent heating data were obtained during reentry.

<sup>1</sup> See footnote at the end of table.

**Major NASA Launches—Continued**

Name, date launched, mission	Vehicle	Site <sup>1</sup>	Results
Nimbus B, May 18..... The 3d Nimbus, designed to carry advanced experiments for long-range weather forecasting. It would also obtain oceanographic data transmitted by buoys as the spacecraft passed over them.	Thorad-Agena D.	WTR...	Range safety officer destroyed the vehicle after about 2 minutes of its flight. Probable cause of failure was a mechanical misalignment of the Thor yaw rate gyro. Parts of the spacecraft were recovered early in October.

**Non-NASA Missions**

Explorer XXXVII, Mar. 5..... A satellite to measure and monitor the sun's X-rays and selected solar ultraviolet emissions.	Scout.....	WI.....	This 2d joint Naval Research Laboratory-NASA spacecraft was monitoring the sun's energetic X-ray emissions and providing real-time solar data. (Apogee 545 miles; perigee 324 miles.)
ESRO-IIB (IRIS), May 16..... International scientific satellite carrying English, French, and Dutch experiments to investigate cosmic rays and solar X-rays.	do.....	WTR...	Built by the European Space Research Organization (ESRO), the satellite was launched cooperatively into a nearly polar orbit 215 to 680 miles. All of the experiments were working as designed.

<sup>1</sup>ETR—Eastern Test Range, Cape Kennedy, Fla.  
WTR—Western Test Range, Point Arguello, Calif.  
WI—Wallop Island, Va.

## Appendix P

### NASA Launch Vehicles

Vehicle	Stages	Payload in pounds			Principal use
		345-mile orbit	Escape	Mars/Venus	
Scout.....	4	310 .....			Launching small scientific satellites, reentry experiments, and probes (Explorer XXX, SERT ion engine, SECOR V, French-built FR-1).
Delta.....	3	880	100	120	Launching scientific, meteorological, and communications satellites (TIROS IX, Orbiting Solar Observatories—OSO I and II, Ariel, Telstar I, Relay, Syncom II, Interplanetary Monitoring Platforms (Explorers XXI and XXVIII), Energetic particles satellite (Explorer XXVI).
Thrust Augmented Delta (TAD). .	3	1,300	250	220	Launching scientific, meteorological, communications, and bioscience satellite, and lunar and planetary probes (Pioneer VI, TIROS M, TIROS operational satellites OT-3 and OT-2, Syncom III, Commercial Communications Satellite Early Bird I, Radioastronomy Explorer, Biosatellites A-F, INTELSAT I and II communications satellites, international satellite for ionospheric studies—ISIS).
Thrust Augmented Thor-Agena (TAT). .	2	2,200 .....			Launching geophysics and astronomy and applications satellites (OGO C, D, and F, and Nimbus B2 and D and SERT II).
Atlas-Agena.....	2½	6,000	950	600	Launching heavy scientific satellites, and lunar and planetary probes (Rangers VII, VIII and IX, Mariners III and IV, OGO V—last flight—vehicle being phased out).
Atlas-Centaur.....	2½	9,900	2,600	1,600	Launching medium-weight unmanned spacecraft (Mariner, ATS, OAO, and Pioneer).
Saturn IB.....	2	1 40,000 .....			Launching Project Apollo spacecraft.
Saturn V.....	3	1 270,000	100,000	80,000	Do.

<sup>1</sup> For 100 nautical mile orbit.

## Appendix Q

### Institutions Currently Participating in NASA's Predoctoral Training Program

(June 30, 1968)

Adelphi University	Georgetown University
Alabama, University of	Georgia Institute of Technology <sup>1</sup>
Alaska, University of	Georgia, University of
Alfred University	Hawaii, University of
Arizona State University	Houston, University of
Arizona, University of	Howard University
Arkansas, University of	Idaho, University of
Auburn University	Illinois Institute of Technology
Baylor University	Illinois, University of
Boston College	Indiana University
Boston University	Iowa State University
Brandeis University	Iowa, University of
Brigham Young University	Johns Hopkins University
Brooklyn, Polytechnic Institute of	Kansas State University
Brown University	Kansas, University of <sup>1</sup>
California Institute of Technology	Kent State University
California, University of, at Berkeley	Kentucky, University of
California, University of, at Los Angeles	Lehigh University
California, University of, at Riverside	Louisiana State University
California, University of, at San Diego	Louisville, University of
California, University of, at Santa Barbara	Lowell Technological Institute
Carnegie-Mellon University	Maine, University of
Case Western Reserve University	Marquette University
Catholic University of America	Maryland, University of
Chicago, University of	Massachusetts Institute of Technology
Cincinnati, University of	Massachusetts, University of
Clark University	Miami, University of
Clarkson College of Technology	Michigan State University
Clemson University	Michigan Technological University
Colorado School of Mines	Michigan, University of
Colorado State University	Minnesota, University of
Colorado, University of	Mississippi State University
Columbia University	Mississippi, University of
Connecticut, University of	Missouri, University of
Cornell University <sup>1</sup>	Missouri, University of, at Rolla
Dartmouth College	Montana State University
Delaware, University of	Montana, University of
Denver, University of	Nebraska, University of
Drexel Institute of Technology	Nevada, University of
Duke University	New Hampshire, University of
Duquesne University	New Mexico State University
Emory University	New Mexico, University of
Florida State University	New York, The City University of
Florida, University of	New York, State University of, at Buffalo
Fordham University	New York, State University of, at Stony Brook
George Washington University	

See footnotes at end of table.

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New York University	Stanford University <sup>1,3</sup>
North Carolina State of the University of North Carolina	Stevens Institute of Technology
North Carolina, University of	Syracuse University
North Dakota State University	Temple University
North Dakota, University of	Tennessee, University of
Northeastern University	Texas A&M University
Northwestern University	Texas Christian University
Notre Dame, University of	Texas Technological College
Ohio State University	Texas, University of
Ohio University	Toledo, University of
Oklahoma State University	Tufts University
Oklahoma, University of	Tulane University
Oregon State University	Utah State University
Pennsylvania State University	Utah, University of
Pennsylvania, University of	Vanderbilt University
Pittsburgh, University of <sup>2</sup>	Vermont, University of
Princeton University	Villanova University
Purdue University <sup>1</sup>	Virginia Polytechnic Institute
Rensselaer Polytechnic Institute	Virginia, University of
Rhode Island, University of	Washington State University
Rice University	Washington University (St. Louis)
Rochester, University of	Washington, University of
Rutgers—The State University	Wayne State University
St. Louis University	West Virginia University
South Carolina, University of	William and Mary, College of
South Dakota, University of	Wisconsin, University of
Southern California, University of <sup>2</sup>	Worcester Polytechnic Institute
Southern Illinois University	Wyoming, University of
Southern Methodist University	Yale University
Southern Mississippi, University of	Yeshiva University

<sup>1</sup> Institutions receiving training grants specifically for engineering systems design.

<sup>2</sup> Institutions receiving training grants specifically for administration and management.

<sup>3</sup> Institutions receiving training grants specifically for laser technology.

## Appendix R

### Grants and Research Contracts Obligated\*

(January 1-June 30, 1968)

		Agreement period	Amount
<b>ALABAMA:</b>			
NsG-381.....	Alabama, University of, R. HERMANN, G. CROWER..... (NGR-01-002-001) Research in the aerospace physical sciences.	3/69- 2/71	\$150,000
NAS8-2585.....	Alabama, University of..... Investigation of surface ionization on metallic surfaces. Study of forces that interact between metal surface & the absorbed atom.	2/62- 3/69	40,000
NAS-11202.....	Alabama, University of..... Study of the measurement of earth tremors, resulting from large rocket firings.	3/64-10/69	50,000
NAS8-20159.....	Alabama, University of..... Study of cold welding in ultra high vacuum as a function of surface contamination.	6/65- 7/69	25,000
NAS8-20172.....	Alabama, University of..... Study and analysis of the FM/FM and SS/FM telemetry systems for the Saturn vehicle.	6/65- 5/69	59,000
	..... Experimental analysis of low profile flange connections.	4/67- 4/68	5,000
NAS8-21143.....	Alabama, University of..... Two phase flow & heat transfer in porous beds under variable body forces.	5/67- 1/69	100,000
NAS8-21321.....	Alabama, University of..... Preparation of a program history of Project Saturn.	5/68-11/70	100,000
NAS8-21480.....	Alabama, University of..... Dynamic analysis of stability and deployment of inflatable shell structures.	6/68- 6/69	25,000
NSR-01-003-005...	Auburn University, R. I. VACHON..... A summer institute in space-related engineering.	1/68-12/68	111,000
NSR-01-003-025...	Auburn University, R. I. VACHON..... A summer program in systems design engineering.	1/68-12/68	100,060
NAS8-11184.....	Auburn University..... Research telemetering, measuring & radio frequency systems.	3/64- 6/69	30,000
NAS8-11344.....	Auburn University..... Investigation of optimum design configurations for DC operational amplifiers.	1/65- 3/69	32,000
NAS8-20004.....	Auburn University..... An investigation of the strapped-down inertial system.	1/65- 2/69	40,000
NAS8-20104.....	Auburn University..... Analytical study of problems involving control of large space vehicles.	4/65- 3/69	80,000

\*The grants listed in this appendix are reported to the Congress in compliance with the requirements of the grants statute, 42 U.S.C. 1891-93 (72 Stat. 1793).

Contracts have prefix NSR or NGR ; grants have prefix NsG or NGR ; transfer of funds to Government agencies have prefix R. Earlier grants and contracts are listed in appendices of previous NASA Semiannual Reports to Congress.

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		<i>Agreement period</i>	<i>Amount</i>
<b>ALABAMA:</b>			
NAS8-20175.....	Auburn University..... Study of orbital perturbations forces.	6/65- 4/69	\$10,000
NAS8-20765.....	Auburn University..... Studies concerning frequency modulated (FM) telemetry systems for 2.2 to 2.3 Giazhertaz.	5/67- 6/69	27,000
NAS8-21368.....	Auburn University..... Sensitivity analysis of Saturn V elastic boosters.	6/68- 6/69	17,000
<b>ALASKA:</b>			
NsG-201.....	Alaska, University of S. CHAPMAN, SUND-ICHI AKASOFU..... (NGR-02-001-001) Theoretical study of the ring current and geomagnetic field phenomena.	1/68-12/68	50,000
NGR-02-001-027.....	Alaska, University of W. B. MURCRAY..... Spectrophotometry of planetary atmospheres from the X-15 rocket airplane.	1/68-12/68	50,000
<b>ARIZONA:</b>			
NAS8-21397.....	Arizona State University..... Experimental measurements using the laser doppler velocity instrument.	4/68- 4/69	10,000
NsG-399.....	Arizona State University, C. B. MOORE..... (NGR-03-001-001) Investigate, develop, evaluate and improve procedures for sampling, characterizing, and classifying meteorite specimens.	3/68- 2/71	35,061
NGR-03-001-033.....	Arizona State University, D. A. GYORGY..... Heat transfer between surfaces in contact.	3/68- 6/68	11,418
NsG-161.....	Arizona, University of G. P. KUIPER..... (NGR-03-002-002) Selenodioic and physical studies of lunar surface.	6/68- 5/71	206,891
NsG-490.....	Arizona, University of L. E. WEAVER..... (NGR-03-002-006) Research in the application of modern automatic control theory to nuclear rocket dynamics and control.	7/68- 6/71	93,661
NsG-628.....	Arizona, University of S. BASHWIN..... (NGR-03-002-017) Studies in optical spectroscopy.	11/67-10/68	85,000
NsG-646.....	Arizona, University of G. A. KORN..... (NGR-03-002-024) Experimental and theoretical investigations of advanced hybrid (digital-analog) computing techniques and devices.	2/68- 1/69	21,747
NsG-732.....	Arizona, University of A. B. MEINEL, W. G. TIFFET..... (NGR-03-002-032) General studies related to photographic and photoelectric signal detection in space.	2/68- 3/69	125,000
NGR-03-002-068.....	Arizona, University of R. W. LANSING..... Electrophysiological and performance measures of visual excitability cycles in man.	11/67-10/68	15,524
NGR-03-002-071.....	Arizona, University of T. BOWEN..... Cosmic ray investigations of elementary particle phenomena at very high energies.	2/68- 1/69	110,000
NGR-03-002-081.....	Arizona, University of A. M. J. GEHRELS..... Photometry and polarimetry of minor planets.	4/68- 3/69	22,264
NGR-03-002-115.....	Arizona, University of L. E. WEAVER..... State variable feedback design of guidance control systems for aerospace vehicles.	2/68- 6/69	26,912
NGR-03-002-122.....	Arizona, University of E. ROEMER..... Astrometric and astrophysical investigations of comets, minor planets, and satellites.	5/68- 4/69	24,825
NGL-03-002-136.....	Arizona, University of L. P. HUELSMAN..... Analysis and synthesis of distributed-lumped-active networks by digital computer.	9/68- 8/70	26,000
NGR-03-002-153.....	Arizona, University of W. G. TIFFET..... Feasibility and preliminary design definition for a lunar surface optical environment and experimental package.	6/68- 5/69	50,000
NGR-03-002-155.....	Arizona, University of B. M. HERMAN..... Optimization of solutions of the equation of radiative transfer for atmospheric processes including emission, absorption, polarization, and multiple MIE scattering, and applications to simulated satellite measurements.	5/68- 4/69	50,000

		<i>Agreement period</i>	<i>Amount</i>
<b>ARIZONA—Continued</b>			
NSR-03-002-123...	Arizona, University of, M. D. KELLER..... Case history of the Langley Research Center, 1917-1947.	3/68- 8/68	\$6,700
NSR-03-002-163...	Arizona, University of, W. G. TIFFET..... Support study of manned space astronomy.	4/68- 3/69	74,660
<b>CALIFORNIA:</b>			
NsG-40.....	California Institute of Technology, H. P. LIEPMANN.....	2/68- 1/71	60,000
(N G R -05-002-002)	Investigation of fluid mechanics of rarified gases by extending shock techniques into the low pressure regime.		
NsG-56.....	California Institute of Technology, H. BROWN.....	12/67-11/70	157,471
(N G R -05-002-003)	Investigation of problems in lunar and planetary exploration.		
NsG-426.....	California Institute of Technology, R. B. LEIGHTON.....	4/68- 3/71	257,232
(N G R -05-002-007)	Space related research in selected fields of physics and astronomy, including cosmic rays, interplanetary magnetic fields, solar physics, theoretical astrophysics, planetary spectroscopy and infrared astronomy.		
NGR-05-002-084...	California Institute of Technology, L. T. SILVER..... Investigation in the isotopic systems of uranium, thorium and lead in lunar material.	12/67- 6/68	150,000
NGR-05-002-092...	California Institute of Technology, G. NEUGERAUER..... X-ray astronomy observations from sounding rockets.	12/67-11/68	75,000
NGR-05-002-100...	California Institute of Technology, M. A. NICOLET..... Space charge effects in current transport.	4/68- 3/69	22,200
NSR-05-002-071...	California Institute of Technology, H. ZIRIN..... Feasibility study for large aperture solar telescope to fly on Apollo telescope mount (ATM) system.	4/68- 4/69	49,913
NGR-05-002-107...	California Institute of Technology, A. YARIV..... Research in nonlinear optics and quantum electronics.	11/67-10/68	35,000
NAS5-9312.....	California Institute of Technology..... Cosmic ray experiment for the orbiting geophysical observatories program, OGO-F mission.	3/66- 6/68	17,000
NAS5-11066.....	California Institute of Technology..... Imp-H&J electron isotope spectrometer experiment.	6/68- 6/69	40,000
NAS9-7963.....	California Institute of Technology..... Determine lead isotopes, concentrations of u th pb and their occurrence in minerals.	6/68- 7/69	88,000
NAS9-8074.....	California Institute of Technology..... Determine k ar rb sr and rare gas content.	6/68- 6/69	194,000
NGR-05-013-010...	California State College (Long Beach), K. P. LUKE..... Application of electron diffraction and retarding potential techniques to the investigation of electron reflection properties of clean and gas-covered metal surfaces.	4/68- 3/69	10,106
NsG-101.....	California, University of (Berkeley), M. CALVIN..... Studies of reflection spectra, meteorite analysis, paleo-biochemistry, and biochemical evolution as bases for studying extraterrestrial life.	11/68-10/70	325,000
(N G R -05-003-003)			
NsG-243.....	California, University of (Berkeley), S. SILVER..... Interdisciplinary space oriented research in the physical, biological, engineering, and social sciences.	2/68- 1/71	70,000
NsG-354.....	California, University of (Berkeley), C. A. DESOER, L. A. ZADEK, E. POLAK..... Advanced theoretical and experimental studies in automatic control and information systems.	1/68-12/68	60,000
(N G R -05-003-016)			
NsG-387.....	California, University of (Berkeley), K. A. ANDERSON..... Study of high energy radiation associated with solar flares and Auroral zone phenomena.	2/68- 1/70	128,303
(N G R -05-003-017)			
NGL-05-003-016...	California, University of (Berkeley), C. A. DESOER..... Advanced theoretical and experimental studies in automatic control and information systems.	1/69-12/70	60,000
NGL-05-003-024...	California, University of (Berkeley), N. PACE..... Primate hemodynamics and metabolism under conditions of weightlessness, for the purpose of defining and verifying an experiment suitable for use in a bio-satellite.	8/68- 7/70	250,000

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CALIFORNIA—Continued	<i>Agreement period</i>	<i>Amount</i>
NGR-05-003-067.. California, University of (Berkeley), W. B. N. BERRY.....	Study of growth in recent and fossil invertebrate exoskeletons and its relationship to tidal cycles in the earth-moon system.	7/68- 6/69      \$15,000
NGR-05-003-089.. California, University of (Berkeley), D. H. CALLOWAY....	Investigation of the nutritional properties of Hydrogenomonus eutropha.	1/68-12/68      19,737
NGR-05-033-118.. California, University of (Berkeley), R. OSTWALD.....	Nutritional requirements and breeding behavior of perognathus.	5/68- 8/68      6,400
NGR-05-003-125.. California, University of (Berkeley), C. W. CHURCHMAN..	A study of technological and urban management, with particular emphasis on applying space technology and related technological knowledge to the solution of urban problems.	1/68-12/68      50,000
NGR-05-003-143.. California, University of (Berkeley), D. J. SAKRISON, V. ALGAZI.	Optimization of design of space experiment from the standpoint of data processing.	2/68- 1/69      30,000
NGR-05-003-220.. California, University of (Berkeley), A. N. KAUFMAN....	Plasma kinetic theory.	12/67-11/68      20,000
NGR-05-003-232.. California, University of (Berkeley), D. H. CALLOWAY....	Interrelationships among host, intestinal microflora, and diet.	1/68-12/68      50,000
NGR-05-003-266.. California, University of (Berkeley), S. SILVER.....	Auroral data reduction.	5/68- 4/69      20,000
NGR-05-003-272.. California, University of (Berkeley), C. H. TOWNES.....	Research in radiation physics.	3/68- 2/69      100,000 3/69- 2/71      100,000
NGR-05-003-273.. California, University of (Berkeley), S. P. SILIBERTO.....	Satellite orbit study.	4/68- 3/69      21,800
NGR-05-003-275.. California, University of (Berkeley) H. P. SMITH.....	Dynamical theory of low energy electron diffraction.	4/68- 3/69      18,672
NGR-05-003-278.. California, University of (Berkeley) C. S. BOWYER.....	Study of x-ray emission from selected regions of the southern hemisphere sky.	1/68- 7/68      39,367
NGR-05-003-285.. California, University of (Berkeley) C. L. TIEN.....	Phase I of research entitled "Investigation of Radiation and Conduction of Solids for Spacecraft Heat Transfer Applications—Phase I".	6/68- 5/69      28,700
NSR-05-003-100.. California, University of (Berkeley) A. E. WHITFORD.....	Development of low noise photomultiplier tubes for astronomical applications.	10/67-11/68      85,000
NAS2-4915..... California, University of (Berkeley).....	Investigate role of selenium in nutrition and physiology of neural tissues.	6-68- 6/69      10,000
NSA2-4996..... California, University of (Berkeley).....	Reports on "Preliminary Study of Antennas for Orbital Lunar Electromagnetic Experiment" and "Theoretical Calculations of the Electromagnetic Response of a Radially Layered Model Moon".	6/68- 2/69      8,000
NSA5-2222..... California, University of (Berkeley).....	Instrumentation & support for experiment in solar cosmic ray for S 49 observatory satellite.	3/62- 6/68      22,000
NAS5-9091..... California, University of (Berkeley).....	Neher-type ion chamber experiment.	1/65- 6/69      35,000
NAS5-9094..... California, University of (Berkeley).....	Instrumentation & associated equipment for energetic radiations from solar flares experiment for the OGO Programs OGO-E Mission.	1/67- 4/70      10,000
NAS5-10362..... California, University of (Berkeley).....	Radiation measurement experiment for ATS-E.	5/67- 6/69      11,000
NAS8-11468..... California, University of (Berkeley).....	Study of heating by radiation from exhaust gases.	6/64- 3/69      13,000

		<i>Agreement period</i>	<i>Amount</i>
CALIFORNIA—Continued			
NAS8-21407	California, University of (Berkeley) Asynptotic attitude study of orbiting vehicles.	5/68- 3/69	\$75,000
NAS8-21432	California, University of (Berkeley) Lunar surface engineering properties experiment definition.	6/68- 7/69	99,000
NAS9-7381	California, University of (Berkeley) Lunar receiving laboratory organic mass spectrometry development program.	9/77- 6/68	11,000
NGL-05-004-002	California, University of (Davis) J. L. INGRAHAM An investigation of the genetic characteristics of microbial growth at low temperatures.	7/68- 6/72	46,468
NGR-05-004-008	California, University of (Davis) A. H. SMITH, C. F. KELLY Investigation of the physiological effects of chronic acceleration.	2/68- 1/69	80,000
NGR-05-004-026	California, University of (Davis) L. D. CARLSON Peripheral volume measurements as indices of peripheral circulatory factors in the cardiovascular orthostatic response.	11/67-10/68	46,590
NGR-05-004-031	California, University of (Davis) L. D. CARLSON A systems analysis study of the properties of veins.	4/67- 3/68 4/68- 3/71	37,273 71,273
NGR-05-004-038	California, University of (Davis) R. E. SMITH Circadian rhythms in primates as influenced by latitude, longitude, photoperiod and stress.	1/68-12/68	40,000
NAS2-5057	California, University of (Davis) Phase 1 report on orbital flight effects on calcium kinetics.	6/68-12/68	70,000
NsG-237	California, University of (Los Angeles) W. F. LIBBY Interdisciplinary space oriented research in the physical, biological, and engineering sciences.	4/68- 3/71	200,000
NsG-249	California, University of (Los Angeles) T. A. FARLEY, W. F. LIBBY, P. J. COLEMAN	10/67- 9/69	110,000
(NGR-05-007-004)	Theoretical and experimental investigations of particles and fields in space, including construction of prototype instrumentation.		
NsG-502	California, University of (Los Angeles) J. D. FRENCH, W. R. Adey.	10/67- 6/68	100,000
(NGR-05-007-011)	Neurophysiological and behavioral studies of chimpanzees, including establishment of a group of implanted animals suitable for space flight.		
NGL-05-007-005	California, University of (Los Angeles) G. W. WETHERILL Isotopic chemistry of meteorites, including studies of variation in isotopic abundance among discrete specimens.	9/67- 8/70	41,688
NGL-05-007-006	California, University of (Los Angeles) G. C. KENNEDY Studies on the high pressure solid phases of inert gases, particularly as they might relate to planetary interiors.	10/67- 9/70	45,288
NGR-05-007-041	California, University of (Los Angeles) Z. SEKABA Feasibility studies of coordinated radiation experiments from meteorological satellites.	5/68- 4/69	41,480
NGR-05-007-046	California, University of (Los Angeles) L. H. ALLER Solar elements, their physical parameters and abundances.	5/68- 4/69	69,990
NGL-05-007-049	California, University of (Los Angeles) D. B. LINDSLEY Neurophysiological studies of perception.	7/68- 6/70	55,000
NGR-05-007-065	California, University of (Los Angeles) P. J. COLEMAN Reduction and analysis of data from Mariner IV magnetometer investigations.	4/68- 3/69 4/69- 3/71	99,910 99,900
NGR-05-007-066	California, University of (Los Angeles) A. Y. F. WONG Investigation of interaction between ion beams and plasmas.	5/68- 4/69	30,000
NGR-05-007-077	California, University of (Los Angeles) I. R. KAPLAN Investigation of techniques for analysis of ancient sediments and extraterrestrial materials.	10/67- 7/68	40,675

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		<i>Agreement period</i>	<i>Amount</i>
CALIFORNIA—Continued			
NGR-05-007-091...	California, University of (Los Angeles) Y. Mintz, A. Arakawa.	1/68-12/68	\$19,379
NGR-05-007-116...	California, University of (Los Angeles) A. BANOS.....	12/67- 2/69	29,897
NGR-05-007-122...	California, University of (Los Angeles), A. V. BALA- KRISHNAN.	10/67-11/68	28,100
NGR-05-007-133...	California, University of (Los Angeles), H. SOBEL.....	6/68- 5/70	23,611
NGR-05-007-161...	California, University of (Los Angeles), F. A. HAAK....	11/67-10/68 11/68-10/70	25,000 25,000
NGR-05-007-169...	California, University of (Los Angeles), P. E. CLOUD....	8/67- 7/68	40,000
NGR-05-007-174...	California, University of (Los Angeles), K.C. HAMNER..	5/68- 4/69	25,450
NGR-05-007-187...	California, University of (Los Angeles), J. J. VIDAL..	2/68- 1/69	29,876
NGR-05-007-190...	California, University of (Los Angeles), C. F. KENNELL	2/68- 1/69	33,380
NGR-05-007-195...	California, University of (Los Angeles), J. D. FRENCH..	4/68- 3/71	200,000
NGR-05-007-200...	California, University of (Los Angeles), L. P. McNAMEE..	1/68- 7/68	10,000
NGR-05-007-201...	California, University of (Los Angeles) L. P. McNAMEE..	1/68- 7/68	10,000
NSR-05-007-089...	California, University of (Los Angeles), J. D. FRENCH..	12/67-11/68	27,600
NSR-05-007-176...	California, University of (Los Angeles), A. V. BALA- KRISHNAN.	1/68-12/68	75,400
NAS2-2503.....	Summer 1968 NASA Faculty Fellowship Program.		
NAS2-2503.....	California, University of (Los Angeles).....	2/65- 1/70	350,000
NAS5-9097.....	Monitoring brain functions and performance in the primate under prolonged weightlessness: P-1001.		
NAS5-9097.....	California, University of (Los Angeles) .....	1/67-12/68	20,000
NAS5-9098.....	Trapped particles experiment for the OGO Program. OGO-E Mission.		
NAS5-9098.....	California, University of (Los Angeles).....	1/67-12/68	46,000
NAS5-9098.....	Tri-axial fluxgate magnetometer experiment for the Orbiting Geophysical Observatories Program. OGO-E Mission.		
NAS5-9098.....	California, University of (Los Angeles).....	1/65- 3/68	24,000
NAS5-9098.....		1/65- 3/68	63,000
NAS5-9308.....	Development and fabrication of instrumentation, ground support and stimuli equipment, and field sup- port for the trapped and precipitating electrons exper- iment for the orbiting geophysical observatories, mission F.		
NAS5-9570.....	California, University of (Los Angeles).....	3/66- 6/68	9,000
NAS5-9570.....	A magnetometer experiment for the application technology satellite.		
NAS9-7882.....	California, University of (Los Angeles).....	6/65- 1/67	70,000
NAS9-7882.....	Preparation and submission of reports for a bioge- ological study of lunar samples.		
		6/68-12/69	56,000

		<i>Agreement period</i>	<i>Amount</i>
<b>CALIFORNIA—Continued</b>			
NAS9-8095.....	California, University of (Los Angeles).....	6/68-12/69	\$80,000
	Determine isotopes of rb sr r and pb by mass spectrometry.		
NAS9-8096.....	California, University of (Los Angeles).....	6/68-12/69	60,000
	Preparation for chemical studies of returned lunar material.		
N G R - 0 5 - 0 0 8 - 0 0 5 .....	California, University of (Riverside), J. CALLAWAY.....	2/68- 1/69	13,000
	Atomic scattering theory.		
NsG-317.....	California, University of (San Diego), G. ARRHENIUS.....	3/68- 2/71	36,000
(N G R - 0 5 - 0 0 9 - 0 0 2)	Study of the composition and structure of meteorites, including the use and refinement of x-ray microspectrometric and microdiffraction techniques.		
NsG-318.....	California, University of (San Diego), L. E. PETERSON.....	12/67-11/69	42,000
(N G R - 0 5 - 0 0 5 - 0 0 3)	Studies for x-ray and gamma ray astronomy.		
NsG-322.....	California, University of (San Diego), H. E. SUESS.....	7/68- 2/71	64,000
(N G R - 0 5 - 0 0 9 - 0 0 5)	Investigation of the cosmic abundances of the elements.		
NsG-357.....	California, University of (San Diego), G. R. BURBIDGE.....	4/68- 3/69	55,000
	Theoretical studies in astrophysics.		
NsG-538.....	California, University of (San Diego), C. E. McILWAIN.....	9/67- 8/69	159,000
(N G R - 0 5 - 0 0 9 - 0 0 7)	Theoretical, analytical and experimental studies of geomagnetically trapped particles, by interpretation of Explorer and Injun satellite data, and by refinement and development of particle detectors, detector systems, and telemetered-data-processing equipment.		
N G R - 0 5 - 0 0 9 - 0 3 0 .....	California, University of (San Diego), R. H. LOVBERG.....	2/68- 1/70	154,117
	Physical processes in the magneto-plasmodynamic arc.		
N G R - 0 5 - 0 0 9 - 0 4 3 .....	California, University of (San Diego), B. NAGY, H. C. UREY.	1/68- 6/68	51,000
	Techniques for organic geochemical analysis of lunar sample materials.		
N G R - 0 5 - 0 0 9 - 0 5 9 .....	California, University of (San Diego), B. Q. DUNTLEY.....	4/68- 3/69	65,000
	Experimental techniques for analyzing visual detection probability of objects in space.		
N G R - 0 5 - 0 0 9 - 0 6 2 .....	California, University of (San Diego), I. M. JACOBS.....	4/68- 3/69	16,169
	Coding studies for deep space communication.		
N G R - 0 5 - 0 0 9 - 0 7 9 .....	California, University of (San Diego), C. W. HELSTROM.....	6/68- 2/69	22,000
	The application of signal detection theory to optics.		
N G R - 0 5 - 0 0 9 - 0 8 1 .....	California, University of (San Diego), W. I. AXFORD.....	1/68-12/68	60,000
	Theoretical studies of fields, particles and plasmas in space.		
N G R - 0 5 - 0 0 9 - 0 8 3 .....	California, University of (San Diego), R. GALAMBOS.....	1/68- 8/68	30,840
	Immunoneurological studies on the brain.		
NAS5-10363.....	California, University of (San Diego).....	5/67- 6/67	7,000
	Experiment to study electric and magnetic fields with energetic electron detectors on ATS-E.		
NAS5-11080.....	California, University of (San Diego).....	9/67- 8/70	44,000
	Cosmic x-ray experiment OSO-H.		
NAS9-7891.....	California, University of (San Diego).....	6/68-10/69	59,000
	Determine cosmic ray and solar particle activation effects.		
NAS9-7892.....	California, University of (San Diego).....	6/68- 8/69	10,000
	Determine microstructure characteristics and composition.		
NAS9-8107.....	California, University of (San Diego).....	6/68-10/69	16,000
	Istopic abundance.		
N G R - 0 2 5 - 0 0 7 .....	California, University of (San Francisco), L. E. EARLEY.....	6/68- 5/69	71,111
	The role of systemic and renal hemodynamics as determinants of sodium excretion and volume regulations.		
NAS2-4744.....	California, University of (San Francisco).....	2/68- 8/68	9,000
	Provide instrumented doas.		

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		<i>Agreement period</i>	<i>Amount</i>
<b>CALIFORNIA—Continued</b>			
NSG-91.....	California, University of (Santa Barbara), W. C. WALKER.....	1/68-12/70	\$25,000
(NGR-05-010-001)	Investigation of the optical parameters of certain solids in the spectral region between 500 and 3000 Angstroms.		
NGR-05-010-010.....	California, University of (Santa Barbara), W. C. GOGEL.....	6/68- 5/69	27,601
	Interrelations of perceived size and distance.		
NSR-05-010-021.....	California, University of (Santa Barbara), W. T. THOMSON.....	12/67-11/68	53,400
	Space technology summer institute.		
NGR-05-061-004.....	California, University of (Santa Cruz), E. M. EVLETH.....	6/68- 5/69	6,500
	Geometrical influences on non-radioactive processes in organic molecules.		
NGR-05-029-001.....	San Francisco, University of, A. FURST.....	5/68- 7/69	400
	Study of the brain amino acids and biogenic amines under various atmospheric mixtures.		
NAS2-4875.....	San Francisco, University of.....	5/68-12/68	6,000
	Analysis of amino acid mixtures by gas chromatography.		
NGR-05-017-012.....	Santa Clara, University of, R. B. YARBROUGH.....	10/67- 9/68	10,000
	Analysis and design of solid-state circuits utilizing the NASA analysis computer program.		
NGR-05-017-013.....	Santa Clara, University of, D. A. OLIVER.....	4/68- 3/69	19,000
	Nonuniformities and instabilities in electrically conducting partially ionized gases in the presence of a magnetic field.		
NGR-05-017-017.....	Santa Clara, University of, S. P. CHAN.....	6/68- 5/69	10,000
	Research on the utilization of topological techniques for modelling microcircuits.		
NSR-05-003-100.....	California, University of (Santa Cruz), A. E. WHITFORD.....	11/67-11/68	85,000
	Instrumentation for spectrophotometry of faint objects.		
NGR-05-018-022.....	Southern California, University of, G. A. BEKEY.....	7/68- 6/69	44,495
	New techniques for analysis of manual control systems.		
NGR-05-018-044.....	Southern California, University of, H. BICHSEL.....	7/68- 6/71	200,000
	Multidisciplinary research in the space-related engineering, physical, biological, and social sciences.		
NSR-05-018-058.....	Southern California, University of, J. W. EHRENREICH.....	7/66- 1/67	2,692
	Exploratory and developmental study for a Southern California Regional Dissemination Center for Technology Utilization.		
NGR-05-018-065.....	Southern California, University of, T. C. JAMES.....	2/68- 7/68	35,000
	Investigation of molecules of interest in stellar and planetary atmospheres.		
NGR-05-018-079.....	Southern California, University of, W. T. KYNER.....	6/68- 9/70	5,000
	Qualitative properties of the orbits of near earth satellites.		
NGR-05-018-093.....	Southern California, University of, A. K. OULIE.....	2/68- 1/69	289,050
	Operation of the Western Research Application Center.		
NGR-05-018-098.....	Southern California, University of.....	7/68- 6/71	200,000
	Multidisciplinary research in management and administration with emphasis on large scale R & D public programs.		
NSR-05-018-067.....	Southern California, University of, D. L. JUDGE.....	3/67-12/68	15,000
	Rocket experiment to measure the extreme ultraviolet dayglow.		
NAS2-2633.....	Southern California, University of.....	1/65- 3/69	120,000
	Monitoring cardiovascular function in the primate under prolonged weightlessness.		
NSG-30.....	Stanford University, O. G. VILLARD.....	1/68- 8/68	50,000
(NGR-05-020-001)	Electron content distribution and temporal variation in the ionosphere by means of scintillation and Faraday rotation of satellite radio transmissions, including consideration of latitudinal effects of magnetic storms.	1/65- 2/68	74,000

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CALIFORNIA—Continued			
NsG-133.....	Stanford University, R. H. CANNON, I. FLUGGE-LOTZ.....	9/67- 8/68	\$80,000
(NGR-05-020-007)	Basic studies on space vehicle attitude control systems.		
NsG-331.....	Stanford University, A. L. SCHAWLOW.....	10/67- 9/69	50,000
(NGR-05-020-013)	Spectroscopy and solid quantum electronics at optical and infrared wavelengths.		
NsG-378.....	Stanford University, W. M. FAIRBANK.....	2/68- 1/69	70,000
(NGR-05-020-015)	Gravitational and resonance experiments on very low-energy free electrons and positrons.		
NsG-582.....	Stanford University, R. H. CANNON, W. M. FAIRBANK, B. O. LANGE.....	4/68- 9/68	180,000
(NGR-05-020-019)	Investigations, theoretical and experimental analyses for a zero-g satellite development, and Schiff gyro test of the general theory of relativity.		
NsG-622.....	Stanford University, A. S. TETELMAN.....	6/68- 5/69	20,000
(NGR-05-020-019)	The mechanism of strengthening and fracture in composite systems.		
NGR-05-020-073..	Stanford University, R. E. KALMAN.....	4/68- 9/69	59,998
	Research on stability and stochastic optimal control.		
NGR-05-020-091..	Stanford University, D. BERSHADER.....	6/68- 5/69	50,000
	Experimental and analytical studies of plasma transport properties.		
NGR-05-020-103..	Stanford University, S. H. HARRIS.....	4/68- 3/69	90,000
	Investigation of laser dynamics, modulation and control by means of intra-cavity time varying perturbation.		
NGR-05-020-137..	Stanford University, L. STRVER, A. KORNBERA.....	1/68- 6/68	25,000
	Structure and function of proteins and nucleic acids.		
NGR-05-020-165..	Stanford University, M. CHODOROW.....	4/68- 3/69	50,000
	Theoretical and experimental investigations of collective microwave phenomena in solids.		
NGR-05-020-209..	Stanford University, T. R. KANE.....	7/68- 6/69	35,000
	Dynamics of the human body in free fall.		
NGR-05-020-234..	Stanford University, A. E. SIEGMAN.....	3/68- 2/69	22,500
	Study of laser frequency stability and spectral purity.		
NGR-05-020-242..	Stanford University, W. A. LITTLE.....	2/68- 1/69	25,000
	Research on the effects of structure upon the electronic behavior of material.		
NGR-05-020-245..	Stanford University, D. BAGANOFF.....	2/68- 1/69	25,000
	Experimental and analytical studies of reflecting shock waves in a real gas.		
NGR-05-020-250..	Stanford University, J. D. BALDESCHWIELER.....	8/68- 7/70	25,000
	Study of abiogenic reaction mechanisms by cyclotron resonance spectroscopy.		
NGR-05-020-258..	Stanford University, H. S. SEIFERT.....	3/68- 2/69	40,000
	Small scale lunar surface personnel transporter employing the hopping mode.		
NGR-05-020-267..	Stanford University, A. D. HOWARD.....	3/68- 2/70	36,000
	Investigation of lunar analogues of fluvial landscapes and possible implications.		
NGR-05-020-272..	Stanford University, P. A. STURROCK.....	7/68-10/68	25,000
	Theoretical study of the solar atmosphere and the structure of active regions.		
NGR-05-020-275..	Stanford University, K. KARAMCHETI.....	1/68-12/68	28,443
	A study of the fluid mechanics of edgetones.	1/69-12/70	30,000
NGR-05-020-276..	Stanford University, V. R. ESHLEMAN.....	10/67- 4/69	66,433
	Reduction and analysis of data from the Mariner V dual frequency receiver experiment.		
NGR-05-020-277..	Stanford University, D. A. DUNN.....	2/68- 6/68	14,000
	Optical scattering methods in laboratory plasma diagnostics.		
NGR-05-020-288..	Stanford University, R. A. HELLIWELL.....	5/68- 4/69	98,568
	Magnetosphere studies on satellite VLF/LF data acquired on OGO-I and OGO-II.		
NSR-05-020-088..	Stanford University, M. ANLIKER.....	3/68- 3/69	140,000
	Summer institute in space-related engineering.		

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CALIFORNIA—Continued			
NSR-05-020-151	Stanford University, W. BOLLAY.....	6/68- 8/68	\$85,100
	A summer program in systems design engineering.		
NGR-05-020-166	Stanford University, A. SCHAWLOW.....	11/67-10/68	35,000
	Investigation of coherent infrared sources of radiation.		
NAS2-3410	Stanford University.....	2/66- 6/69	8,000
	Radio propagation experiment for Project Pioneer.		
NAS2-4671	Stanford University.....	12/67- 6/68	150,000
	Pioneer C post-launch operations.	12/67- 6/68	20,000
NAS2-4686	Stanford University.....	1/68- 8/68	30,000
	Kinetic studies of an excited monatomic gas interacting with radiation.		
NAS5-2131	Stanford University.....	6/68- 6/68	55,000
	Instrumentation for noise survey experiment for eccentric geophysical orbiting observatory.		
NAS5-9309	Stanford University.....	3/66- 6/68	185,000
	VLF polarization experiment for the orbiting geophysical observatory, Mission F(OGO-F).	3/66- 6/68	102,000
NAS5-10102	Stanford University.....	6/66- 2/69	85,000
	Radio propagation studies of the ionosphere.		
NAS9-7020	Stanford University.....	5/67-11/68	25,000
	Preliminary study of atmospheric density measurements by means of satellites.		
NAS9-7313	Stanford University.....	6/67- 3/69	100,000
	Infrared spectrometry studies.		
NAS12-690	Stanford University.....	6/68- 7/69	35,000
	The design and development of a low-cost microwave adaptor.		
NAS12-695	Stanford University.....	5/68- 5/69	40,000
	Design of a drag-free satellite applic. to geod.		
COLORADO:			
NGR-06-002-053	Colorado State University, C. B. WINN.....	7/68- 1/69	21,430
	Theoretical investigation of an electrically propelled geodetic satellite.		
NASr-147	Colorado State University, W. E. MARLATT.....	6/67- 6/68	100,000
(NSR-06-002-003)	Investigation of the temperature and spectral emissivity characteristics of cloud tops and of the earth's surface.		
NAS8-21049	Colorado State University.....	3/67- 6/68	8,000
	Crossed beam weather watch study.		
NGR-06-003-033	Colorado, University of, A. BUSEMANN.....	9/67- 8/68	33,000
	Optimal trajectories between elliptical orbits.		
NGR-06-003-071	Colorado, University of, R. WOLFGANG.....	9/67- 8/69	87,673
	Chemical reactions in the electron-volt region.		
NGR-06-003-083	Colorado, University of, I. HOROWITZ.....	4/68- 3/69	29,275
	Research in adaptive systems.		
NGR-06-003-088	Colorado, University of, R. E. HAYES.....	3/68- 2/69	21,427
	Nonreciprocal semiconductor millimeter wave devices.		
NSR-06-003-085	Colorado, University of, C. BARTH.....	9/67- 6/68	27,972
	Reduce and analyze data from ultraviolet photometer experiment on Mariner V.		
NAS5-3931	Colorado, University of.....	6/64- 7/68	34,000
	Perform research on Orbiting Solar Observatory—E.		
NAS5-9307	Colorado, University of.....	3/66- 6/68	12,000
	Ultraviolet photometer experiment for the Orbiting Geophysical Observatory Mission F (OGO-F).		
NAS5-9327	Colorado, University of.....	3/66- 9/67	68,000
	Ultraviolet photometer experiment for the Orbiting Geophysical Observatory Mission E.		
NsG-518	Denver, University of, S. A. JOHNSON.....	9/67- 8/69	50,000
(NGR-06-004-007)	Multidisciplinary research in space-related science and engineering.	1/68- 9/68	5,000
NGR-06-004-058	Denver, University of, V. L. PATEL.....	5/68- 4/69	13,000
	Study of hydromagnetic disturbances in the geomagnetic field of satellite altitudes.		

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<b>COLORADO—Continued</b>			
NGR-06-004-060..	Denver, University of, J. G. ROEDERER.....	6/68- 5/69	\$20,000
	Study of physical processes which govern the dynamics of geomagnetically trapped radiation.		
NGR-06-004-068..	Denver, University of, L. W. Ross.....	12/67-12/68	9,277
	Effect of pulsed operation on the performance of life support system components.		
NGR-06-004-078..	Denver, University of, A. A. EZRA.....	6/68- 5/71	200,000
	Program for the exploitation of unused NASA patents.		
NSR-06-004-063..	Denver, University of, R. E. DUFFY.....	1/68- 3/69	225,137
	The analysis of information on technology transfer.		
NAS8-21436.....	Denver, University of.....	6/68- 6/59	29,000
	Long range solar flare prediction.		
NAS10-5972.....	Denver, University of.....	6/68-10/68	11,000
	Apollo supporting development study.		
NAS-12-651.....	Denver, University of.....	4/68- 6/69	10,000
	Application of network analysis for system application program to the design of biomedical circuits.		
<b>CONNECTICUT:</b>			
NsG-309.....	Connecticut, University of, D. P. LINDORFF.....	9/67- 8/69	45,000
(N G R-07-002-002)	Analytical and experimental research on reducing the sensitivity of control systems to parameter variations, and on the relative merits of various control system configurations.		
NGL-07-002-002..	Connecticut, University of, D. P. LINDORFF.....	9/67- 8/70	23,000
	Investigation of control of systems with large parameter variations.		
NGR-07-010-002..	Fairfield University, J. H. MCELANEY.....	3/68- 2/69	19,800
	Investigation of energy deposition processes in the upper atmosphere, and the interaction between the mesosphere and the thermosphere.		
NsG-138.....	Yale University, R. C. BARKER.....	1/68-12/68	51,900
(N G R-07-004-005)	Research on low-power, low-speed data storage and processing techniques.		
NsG-163.....	Yale University, V. W. HUGHES.....	10/67- 9/68	15,000
(N G R-07-004-006)	Theoretical research in relativity, cosmology, and nuclear astrophysics.		
NsG-192.....	Yale University, S. R. LIPSKY.....	10/67- 9/68	82,145
(N G R-07-004-008)	Gas-chromatographic systems to analyze certain chemical constituents of surface of moon.		
NGR-07-004-035..	Yale University, W. E. LAMB.....	1/68-12/68	35,000
	Investigation of the basic foundations of masers and lasers.		
NGR-07-004-049..	Yale University, V. SZEBEHELY.....	2/68- 1/69	7,000
	The gravitational n-body problem.		
NGR-07-004-083..	Yale University, V. SZEBEHELY.....	3/68- 2/69	24,925
	Applications of celestial mechanics to space research.		
NGR-07-004-084..	Yale University, R. A. GOLDSBY.....	1/68-12/69	17,930
	Water metabolism as a life detection indicator.		
NGR-07-004-087..	Yale University, F. B. TUTEUR.....	9/67- 8/68	14,000
	Research in time and fuel optimal control systems.		
NGR-07-004-090..	Yale University, R. J. WYMAN.....	1/68-12/68	11,401
	Study of the role of proprioception in the coordination of locomotion.		
NAS9-8032.....	Yale University.....	5/68-11/69	33,000
	Determine by neutron activation analysis those ele- ments having half-lives greater than three days. Lunar sample analysis program.		
NAS9-8072.....	Yale University.....	6/68-12/69	61,000
	Identification of certain organic compounds in lunar material.		
NAS9-8075.....	Yale University.....	6/68- 2/70	43,000
	Examine returned lunar samples for condensed sub- limates.		

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CONNECTICUT—Continued			
NGR-07-004-100	Yale University, J. C. G. WALKER.....	3/68- 2/69	\$13,764
	Theoretical study of charged particles temperatures in the ionosphere.		
DELAWARE:			
NGR-08-001-019	Delaware, University of, T. W. F. RUSSELL.....	5/68- 4/71	50,000
	Two-phase flow and boiling heat transfer problem in viscoelastic fluids.		
DISTRICT OF COLUMBIA:			
NsG-586	Catholic University, C. C. CHANG.....	2/68- 6/68	10,000
(NGR-09-005-005)	Theoretical, analytical and experimental investigations of hydrodynamics of gaseous-core ring-vortex and cylindrical cavity reactors.		
NGR-09-005-022	Catholic University, B. T. DE CICCO.....	5/68- 4/69	25,598
	Genetic studies of hydrogen bacteria and their application to biological life support systems.		
NGR-09-005-025	Catholic University, C. C. CHANG.....	12/67-11/69	126,146
	Diagnostics of accelerating plasma.		
NGR-09-005-054	Catholic University, T. TANAKA.....	11/67-10/68	21,000
	Theoretical investigation of microwave frequency doubling by means of magnetic non-linearity in antiferromagnetic crystals.		
NGR-09-005-055	Catholic University, H. C. KHATRI.....	5/68- 4/69	17,000
	Investigation of stability of distributed parameter systems.		
NSR-09-005-056	Catholic University, C. S. BOWTYER.....	8/67- 5/68	97,628
	Completion of the design and fabrication of the rocket payload for search of the southern hemisphere sky for galactic x-ray sources.		
NSR-09-005-059	Catholic University B. T. FANG.....	2/68- 1/69	99,767
	A summer institute in space-related engineering.		
NsG-603	George Washington University, N. FILIPESCU.....	7/68- 6/69	25,000
(NGS-09-010-008)	Synthesis and spectroscopic properties of rare earth chelates in solvents and polymers for optical masers.		
NSR-09-010-027	George Washington University, C. W. SHILLING.....	1/68-12/68	165,000
	Scientific communication research in space biology.	6/68-12/68	15,000
NSR-09-010-035	George Washington University, C. W. SHILLING.....	1/67- 5/69	98,976
	Design and management of biomedical applications systems for NASA.		
NASw-88	George Washington University.....	6/68- 7/69	18,000
	Data reduction and study.		
NGR-09-011-004	Howard University, H. BRANSON.....	9/67- 8/69	43,000
	Research in space sciences.		
NGR-09-011-006	Howard University, F. SENTLE.....	9/67- 5/68	9,998
	Investigation of infra-red absorption and low angle x-ray scattering of tektites.		
NGR-09-011-017	Howard University, E. W. HAWTHORNE.....	1/68- 1/69	73,788
	Study of neurohumoral control systems operation in adjustment of ventricular performance.		
FLORIDA:			
NsG-224	Florida State University, C. H. BARROW.....	2/68- 1/69	49,958
(NGR-10-004-004)	Polarization of the decameter-wave radiation from Jupiter.		
NsG-247	Florida State University, L MANDELKERN.....	3/68- 2/69	16,994
(NGR-10-004-005)	Study of crystallization, crosslinking and dimensional changes during the crystal-liquid phase transition of oriented polymeric systems.		
NGR-10-004-018	Florida State University, H. GAFFRON.....	7/68- 6/69	32,500
	Photochemical transformation of acetate into algae cell material.		
NGR-10-019-001	Florida Technological University, H. N. REXFORD.....	3/68- 2/69	12,500
	The confinement and propagation of light beams.		
NsG-542	Florida, University of, L. E. GRINTER.....	11/67-10/70	125,000
(NGR-10-005-005)	Multidisciplinary program of research in space-related sciences and technology.		

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<b>FLORIDA—Continued</b>			
NsG-599.....	Florida, University of, A. E. S. GREEN.....	5/68- 4/70	\$50,000
(NGR-10-005-008)	Theoretical atmospheric physics.		
NGR-10-005-036..	Florida, University of, G. E. NEVILL.....	10/68- 9/69	30,000
	Impact of shell type structures with continuous media.		
NGR-10-005-039..	Florida, University of, J. J. HREN.....	3/68- 2/69	30,000
	Investigation of structure with the field ion microscope.	3/68- 2/71	30,000
NGR-10-005-049..	Florida, University of, R. T. SCHNEIDER.....	3/68- 2/69	19,900
	Investigation of spectra in the vacuum UV and soft x-ray region.		
NGR-10-005-057..	Florida, University of, W. B. WEBB.....	5/68- 4/69	20,000
	Studies of electroencephalographic patterns of sleep.		
NGR-10-005-080..	Florida, University of, R. E. HUMMEL.....	5/68- 4/69	23,273
	Electrotransport in thin films.		
NGR-10-005-089..	Florida, University of, R. T. SCHNEIDER.....	1/68-12/68	62,795
	Experimental investigation of a uranium plasma.		
NSG-10-005-047..	Florida, University of, H. BROWN.....	9/67- 8/68	24,999
	Analysis and synthesis of elastomers for use with liquid fluorine.		
NGR-10-007-010..	Miami, University of, E. H. MAN.....	11/67-10/70	200,000
	Multidisciplinary research in Space Sciences.		
NGR-10-007-052..	Miami, University of, K. HARADA.....	10/67- 9/68	23,040
	Study of optical activity in the context of pre-biological chemistry.		
NGR-10-007-054..	Miami, University of, G. MUELLER.....	10/67- 9/68	10,600
	Comparative studies of the organic and inorganic chemistry, mineralogy and petrology of the earth's crust, the meteorites and lunar rocks.		
NGR-10-007-067..	Miami, University of, F. D. KOHLER.....	3/68- 2/71	200,000
	The impact of Soviet and U.S. space and aeronautic programs and policies on societies and systems of the USSR and the U.S.		
MGR-10-007-068..	Miami, University of, F. D. KOHLER.....	5/68- 4/71	120,000
	The correlation of U.S. and Soviet space and oceanographic program.		
NSR-10-008-013... WURMB.	South Florida, University of, H. K. EICHHORN-VON WURMB.	10/67- 6/68	13,080
	A conference on photographic astrometric technique.		
<b>GEORGIA:</b>			
NGR-11-001-009..	Emory University, V. P. POPOVIC.....	5/68- 4/69	50,000
	Cardiovascular adaptation during long-term weightlessness.		
NGR-11-001-016..	Emory University, G. H. BOURNE.....	12/67-11/68	50,000
	Histopathological and histochemical study of sub-human primates.		
NsG-304.....	Georgia Institute of Technology, H. D. EDWARDS.....	6/68- 5/69	40,000
(NGR-11-002-004)	Theoretical and experimental studies of high altitude chemical release.		
NsG-337.....	Georgia Institute of Technology, J. A. KNIGHT.....	1/68-12/71	40,000
(NGR-11-002-005)	Chemical reactivity of hydrogen, nitrogen, and oxygen atoms at temperatures below 100°K.		
NsG-657.....	Georgia Institute of Technology, K. PICA, V. CRAWFORD.....	3/68- 3/71	100,000
(NGR-11-002-018)	Multidisciplinary research in space sciences and technology.		
NGR-11-002-062..	Georgia Institute of Technology, A. BEN HUANG.....	2/68- 1/69	34,836
	Study of non-linear rarefied gas flows by the discrete ordinate method.		
NGR-11-002-065..	Georgia Institute of Technology, A. P. SHEPPARD.....	11/67-10/68	20,114
	Techniques for reducing mixer conversion loss in millimeter wave receivers for communications and radiometry.		
NGR-11-002-081..	Georgia Institute of Technology, V. CRAWFORD.....	6/68- 5/71	30,948
	Phase II—predoctoral design training grant.		

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<b>GEORGIA—Continued</b>				
NAS2-5016.....	Georgia Institute of Technology.....		6/68- 6/69	\$23,000
	Study for improved microwave cavities for polymer and biological ESR measurements.			
NAS8-2473.....	Georgia Institute of Technology.....		9/61- 3/69 9/61- 6/69	40,000 20,000
	Development of new methods & applications to analog computations.			
NAS8-21510.....	Georgia Institute of Technology.....		2/68- 6/68	20,000
	Univac 1108 computer services in support of the computation lab MSFC.			
NGR-11-002-021...	Georgia, University of, D. R. TOMPKINS.....		1/68-12/68	20,000
	A cosmic ray search for fast magnetic charges.			
NAS8-11175.....	Georgia, University of.....		3/64-10/68	24,000
	Analysis of variance with corrected variates and its significance for meteorological statistics.			
NAS8-21002.....	Georgia, University of.....		6/66-6/68	29,000
	NASA computer software management & information center.			
<b>HAWAII:</b>				
NGR-12-001-011...	Hawaii, University of, J. T. JEFFERIES.....		11/67-10/68	397,349
	Research in coronal and chromospheric physics.			
NGR-12-001-042...	Hawaii, University of, S. M. SIEGEL.....		7/68-6/69	50,823
	The performance and capabilities of terrestrial organisms in extreme and unusual gaseous and liquid environments.			
NGR-12-001-046...	Hawaii, University of, W. W. PETERSON.....		1/68-12/68	26,981
	Research in information transmission and processing.			
NGR-12-001-053...	Hawaii, University of, S. M. SIEGEL.....		5/68- 4/69	24,847
	Role of gravitational stress in land plant evolution, the gravitational factor in lignification.			
NGR-12-001-057...	Hawaii, University of, J. T. JEFFERIES.....		7/68- 6/69	201,558
	Research in planetary studies.			
<b>ILLINOIS:</b>				
NsG-96.....	Chicago, University of, E. N. PARKER.....		8/67- 7/70	62,609
	Theoretical investigations of the effect of the solar wind in interplanetary space, and its association with terrestrial phenomena.			
NsG-144.....	Chicago, University of, P. MEYER.....		11/66-10/68	161,000
(NGR-14-001-005)	Composition, energy spectrum and intensity of primary cosmic radiation.			
NsG-179.....	Chicago, University of, J. A. SIMPSON.....		8/67- 7/69	129,000
(NGR-14-001-006)	Experimental and theoretical studies of energetic particles and electrodynamical processes in interplanetary space and in the vicinity of planets.			
NsG-352.....	Chicago, University of, M. H. COHEN.....		3/68- 2/71	85,000
(NGR-14-001-009)	Theoretical and experimental investigations of superconductivity.			
NsG-366.....	Chicago, University of, E. ANDERS.....		10/67- 9/68	100,000
(NGR-14-001-010)	Investigation of origin, age and composition of meteorites.			
NGL-14-001-012...	Chicago, University of, FERNANDEZ-MORAN.....		9/68- 8/71	200,000
	Investigations in space-related molecular biology including considerations of the molecular organizations in luster sounding rocket program.			
NGR-14-001-060...	Chicago, University of, C. R. O'DELL.....		6/68- 8/69	18,421
	Study of comet tails by photoelectric spectrophotometry.			
NGR-14-001-103...	Chicago, University of, J. E. LAMPORT.....		1/68-12/68	216,794
	Advance technical development in support of scientific experiments in space.			
NAS5-3095.....	Chicago, University of.....		11/62-12/68	45,000
	Instrumentation & support for energetic particles experiment for S-50 observatory.		11/62-12/68	50,000
NAS5-9090.....	Chicago, University of.....		12/64-12/68	25,000
	Solid state cosmic ray telescope experiment.			

			<i>Agreement period</i>	<i>Amount</i>
ILLINOIS—Continued				
NAS5-9096	Chicago, University of	Cosmic ray electron experiment, associated equipment and support.	11/64- 4/70	\$80,000
NAS5-9366	Chicago, University of	Low energy heavy cosmic ray particles experiment for OGO-E spacecraft.	6/66- 4/70	52,000
NAS8-21449	Chicago, University of	Definition of Experiment S-74—Primary Cosmic Ray Electrons.	6/68- 2/69	99,000
NAS9-7883	Chicago, University of	Neutron activation analysis and measurements of intrinsic radioactivity.	6/68-12/69	56,000
NAS9-7887	Chicago, University of	Measurement and analysis of two types of trace elements.	6/68- 7/69	79,000
NAS9-7888	Chicago, University of	Determine stable isotope of oxygen study.	6/68-12/69	19,000
NAS9-8080	Chicago, University of	Measure oxidation state of iron radiation damage and al na and fe energy state in crystals.	6/68-12/69	40,000
NAS9-8086	Chicago, University of	Mineralogic-petrographic analysis using microprobe, x-ray diffraction and microscopic methods.	6/68-12/69	30,000
NsG-694	Illinois Institute of Technology, R. WEINSTEIN		2/68-1/69	129,500
(NGR-14-004-008)		Turbulence coefficients and stability studies for the co-axial flow of dissimilar fluids.		
NGR-14-004-006	Illinois Institute of Technology, T. P. TORDA	Investigation of liquid propellants in high pressure and high temperature environments.	1/68-12/68	45,325
NAS7-388	Illinois Institute of Technology	Study the completion of design data for pressurized gas systems. Follow-on to contract NAS7-105 with Stanford Research Institute.	6/65-7/68	25,000
NAS9-7651	Illinois Institute of Technology	Suitability of alycol-water for use in Apollo electric power system.	1/68-6/68	45,000
NAS-12-650	Illinois Institute of Technology	Application of network analysis for system application program to the design of communication circuits.	4/68-5/69	10,000
NsG-511	Illinois, University of (Urbana) S. A. BOWHILL		8/67-7/68	230,000
(NGR-14-005-013)		Investigations and studies of electron density and collision frequency in the lower ionosphere (D and E regions).		
NGR-14-012-004	University of Illinois (Chicago), J. H. BOYER	Nitrogen chemistry significant to primordial systems.	1/68-12/68	60,000
NGR-14-012-012	Illinois, University of (Chicago), P. R. NACHTSHEIM	Turbulent mixing of chemically reacting nonequilibrium gases according to a simplified statistical description.	1/69-12/70	40,000
NGR-14-005-088	University of Illinois (Urbana), G. C. McVITIE	Investigation of relativistic effects on space tracking data.	9/67-8/68	19,274
NGR-14-005-103	University of Illinois (Urbana), J. C. CHATO	Physiological and engineering study of advanced thermoregulatory systems for extravehicular space suits.	6/68-5/69	33,735
NGR-14-005-111	University of Illinois (Urbana), M. L. BABCOCK	A research program to study (1) relations between machine structure and syntactic relations of linguistic elements, and (2) the information bearing parameters displayed in time-domain speech signals.	7/67-6/68	80,000
NAS8-21442	University of Illinois (Urbana)	Study of an orbiting gyro experiment to measure gas density and base molecule surface interaction parameters	6/68-6/69	29,000

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		<i>Agreement period</i>	<i>Amount</i>
<b>ILLINOIS—Continued</b>			
NsG-597.....	Northwestern University, J. A. HYNEK.....	6/68-5/69	\$70,000
(N G R -14-007-016)	Optical study and analysis of transient lunar phenomena.		
NGL-14-007-016	Northwestern University, J. A. HYNEK.....	6/68-5/71	70,000
	Optical study and analysis of transient lunar phenomena.		
N G R -14-007-041	Northwestern University, S. S. HUANG.....	5/68-4/69	23,000
	Study of celestial objects of high angular moments.		
N G R -14-007-058	Northwestern University, J. A. D. COPPER.....	5/68- 4/71	200,000
	Research program in administration.		
N G R -14-007-067	Northwestern University, G. HERRMANN.....	6/68- 5/69	39,391
	Study of the dynamics of mechanical systems coupled to energy sources.		
NAS9-7222.....	Northwestern University.....	6/67- 9/68	40,000
	Apollo applications experiment development—Experiment SO19.		
N G R -14-008-019	Southern Illinois University, P. K. DAVIS.....	6/68-10/69	19,790
	Studies of the flow, bonding and damping characteristics of a squeeze film under dynamic conditions.		
<b>INDIANA:</b>			
NsG-503.....	Indiana University, H. R. JOHNSON.....	1/68-12/70	40,000
(N G R -15-003-002)	A theoretical investigation of the steady-state interaction between radiation and matter in stellar atmospheres.		
N G R -15-003-053	Indiana University, S. MIZELL.....	5/68- 4/69	14,076
	Investigation of control mechanisms in physiological rhythms.		
N G R -15-003-060	Indiana University, E. HOPF.....	2/68- 1/69	13,000
	Applications of functional and complex analysis to non-linear problems.		
N G R -15-003-064	Indiana University, J. R. THOMPSON.....	6/68- 5/69	15,825
	Application of mathematical statistics to digital data analysis.		
N G R -15-003-066	Indiana University, R. W. CAMPBELL.....	2/68- 1/69	30,000
	Study of the impact of the space program on the Soviet economy.		
N G R -15-003-077	Indiana University, W. D. NEFF.....	7/68- 6/69	30,000
	An experimental study of hearing loss and inner ear damage after exposure to sounds of high intensity.		
NSR-15-003-061	Indiana University, A. M. WEIMER.....	2/67-12/67	32,319
	Computer support services for other regional dissemination centers.		
NAS9-8078.....	Indiana University.....	6/68- 8/69	14,000
	Research on visual parameters.		
NAS9-8224.....	Indiana University.....	6/68- 8/69	27,000
	Research on transparencies.		
NsG-339.....	Notre Dame, University of, G. F. D'ALELIO.....	2/68- 1/69	40,000
(N G R -15-004-001)	Synthesis of heat resistant polymers and directed polymerizations.		
NGL-15-004-001	Notre Dame, University of, G. F. D'ALELIO.....	2/68- 1/71	40,000
	Synthesis of heat resistant polymers and directed polymerization.		
N G R -15-004-017	Notre Dame, University of, T. J. STARR.....	3/68- 2/69	50,000
	Applications of the "germfree animal" to space ecology.		
NGR-15-005-022	Purdue University, R. OLDENBURGER.....	7/68- 6/69	21,000
	Flow of single and two phase fluids in lines.		
NsG-301.....	Purdue University, K. L. ANDREW.....	2/68- 1/70	61,000
(N G R -15-005-003)	High precision spectroscopy with applications to the study of the atomic spectra of the carbon group and to the secondary standards in the vacuum ultraviolet and the development of computer methods of data analysis.		

			Agreement period	Amount
<b>INDIANA:</b>				
NsG-553.....	Purdue University, J. C. LINDENLAUB.....		1/68-12/68	\$28,000
(NGR-15-005-006)	Theoretical and experimental studies of sub-optimal second and third generation self-adaptive binary communication systems.			
NSR-15-005-037...	Purdue University, Y. S. TOULOURIAN.....	6/68- 6/69		81,679
	Compilation and analysis of thermal radiative properties data.			
NGR-15-005-058...	Purdue University, B. A. REESE .....	7/68- 6/69		66,000
	Influence of high combustion pressure (4000 psia) upon performance, heat flux, and combustion stability.			
NGR-15-005-063...	Purdue University, E. GOULARD.....	6/68- 8/68		5,000
	Precursor radiation effects of high enthalpy gas streams.			
NGR-15-005-069...	Purdue University, J. MODREY.....	7/67- 6/70		62,000
	Research in engineering design.			
NGR-15-005-077...	Purdue University, D. E. ABBOTT.....	11/67-10/68		11,510
	Transient boundary layer flow on shock tube splitter plates.			
NGR-15-005-087...	Purdue University.....	5/68- 4/69		19,000
	Analysis of spacecraft data systems.			
NAS9-8118.....	Purdue University.....	6/68- 6/69		64,000
	Radiant heat exchange study.			
<b>IOWA:</b>				
NsG-233.....	Iowa, University of, J. A. VAN ALLEN .....	12/67-11/69		100,196
(NGR-16-001-002)	Theoretical and experimental studies related to the particles and fields associated with the major bodies of the solar system and with interplanetary space.			
NGL-16-001-002...	Iowa, University of, J. A. VAN ALLEN .....	12/68-11/70		200,000
	Theoretical and experimental studies related to the particles and fields associated with the major bodies of the solar system and with interplanetary space.			
NGR-16-001-043...	Iowa, University of, D. C. MONTGOMERY & D. A. GURNETT .....	12/67-11/68		49,997
	Waves in plasmas.			
NAS1-8141.....	Iowa, University of.....	6/68-11/70		94,000
	Post-launch, experimenters' data reduction and analysis for Injun-Explorer, Mission C.			
NAS1-81446.....	Iowa, University of.....	6/68-12/70		91,000
	Acquisition of government facilities.			
NAS5-2054.....	Iowa, University of.....	8/62- 6/68		25,000
	Instrumentation for a trapped radiation experiment for the S-49, S-49A.			
NAS5-9074.....	Iowa, University of.....	12/64-12/68		25,000
	Low energy particle detector experiment.			
NAS5-9076.....	Iowa, University of.....	12/64- 6/68		23,000
	Electron & proton experiment.			
NAS5-10625.....	Iowa, University of.....	6/68-11/69		232,000
	Injun V spacecraft control and data acquisition.			
NAS5-11039.....	Iowa, University of.....	6/68- 6/72		193,000
	Imp-I low energy electron and proton experiment.			
NAS5-11064.....	Iowa, University of.....	5/68- 6/64		1,000
	Low energy electrons and protons experiment for Imp-H&J.			
<b>KANSAS:</b>				
NGR-17-001-026...	Kansas State University, D. WILLIAMS.....	12/68-11/70		25,000
	Infrared laboratory studies of synthetic planetary atmosphere.			
NGR-17-001-034...	Kansas State University, L. T. FAN.....	6/68- 5/69		30,000
	Investigate optimization of life support systems and their systems reliability.			
NGL-17-002-001...	Kansas, University of, W. P. SMITH.....	4/68- 3/71		100,000
	Interdisciplinary studies in space science and technology.			
NGR-17-002-047...	Kansas, University of, K. H. LENZEN.....	6/68- 5/69		10,380
	Investigation of aeroelastic effects in aerospace vehicles.			

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		<i>Agreement period</i>	<i>Amount</i>
<b>KANSAS—Continued</b>			
NGR-17-002-052	Kansas, University of, W. P. SMITH.....	5/68- 4/71	\$45,000
	Phase II (project implementation, NASA traineeships in engineering design.)		
NGR-17-004-012	Kansas, University of, K. H. LENZEN.....	10/67-12/67	3,000
	Response on aerospace vehicles to gusts and buffeting.		
NGR-17-003-008	Wichita State University, F. T. SUN.....	5/67- 6/68	13,938
	Application of the hodograph method to the solution of orbit and trajectory problems in space flight.		
<b>KENTUCKY:</b>			
NsG-456	Kentucky, University of, K. O. LANGE.....	2/68- 1/71	149,963
(NGR-18-001-003)	An investigation of gravity level preferences and the effects of gravitational forces on small animals and primates, and of techniques for related space flight experiments.		
NGR-18-001-017	Kentucky, University of, D. C. LEIGH.....	11/68-10/69	10,000
	Thermo-mechanical investigations of non-Newtonian fluids.		
NGR-18-001-038	Kentucky, University of, M. H. LEIPOLD.....	5/68- 4/69	9,305
	Investigation of the interaction of cracks with micro- structure in polycrystalline ceramics.		
NAS9-8017	Kentucky, University of.....	5/68-11/69	29,000
	Analysis of major rock forming elements by 14 mev neutron activation. Lunar sample analysis program.		
NAS9-8098	Kentucky, University of.....	6/68-11/69	68,000
	Thermal radiation characteristics and thermal conduc- tivity of lunar materials.		
NGR-18-002-005	Louisville, University of, W. J. McGLOTHLIN.....	3/68- 2/71	65,000
	Multidisciplinary space-related research in the physical, engineering and life sciences.		
NGR-18-002-008	Louisville, University of, E. A. ALLUISI.....	10/67- 9/68	35,929
	Performance measurements of intellectual functioning.		
<b>LOUISIANA:</b>			
NGR-19-001-012	Louisiana State University, R. W. HUGGETT, K. PINKAU.....	1/68-12/68	120,000
	Cosmic ray investigations utilizing an emulsion cham- ber-calorimeter combination.		
NGR-19-001-016	Louisiana State University, R. W. PIKE.....	1/68-12/68	38,814
	Evaluation of the energy transfer in the char-zone during ablation.		
NGR-19-001-024	Louisiana State University, R. W. RICHARDSON.....	9/67- 8/70	100,000
	Multidisciplinary research in space sciences and engi- neering.		
NAS1-8219	Louisiana State University.....	9/68- 8/71	100,000
	Improvement of computer program for supersonic combustion.		
NGR-19-006-001	Northeast Louisiana State College, D. E. DUPREE.....	6/68- 8/69	17,000
	Study of multivariate functional models by least squares techniques.		
NAS8-20136	Tulane University.....	2/67- 1/69	19,950
	Development of numerical solutions for partial differ- ential equations describing two-dimensional moving boundary problems.		
NAS8-21484	Tulane University.....	5/65- 1/69	30,000
	Solution of systems of nonlinear equations.		
<b>MAINE:</b>			
NsG-338	Maine, University of, T. H. CURRY.....	6/68- 1/71	75,000
(NGR-20-006-001)	Interdisciplinary studies in space-related science and technology.		
<b>MARYLAND:</b>			
NGR-21-023-001	Columbia Union College, E. I. MOHR.....	4/68- 9/68	6,000
	Research in calibration techniques for radiometric devices.		
NsG-193	Johns Hopkins University, W. G. FASTIE.....	7/68- 3/69	70,000
(NGR-21-001-001)	Rocket and laboratory experiments and analysis on the ultraviolet spectra of the upper atmosphere.		

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MARYLAND—Continued			
NsG-361.....	Johns Hopkins University, H. W. Moos.....	8/68- 7/69	\$10,000
(NGR-21-001-002)	Theoretical and experimental investigation of the fundamental properties of rare earth crystals.		
NGR-21-001-035.....	Johns Hopkins University, S. A. WEINSTEIN.....	10/67- 9/68	29,863
	Behavioral regulation of gaseous environments.		
NGR-21-001-043.....	Johns Hopkins University, H. H. SELIGER.....	2/68- 1/69	50,000
	Excited state mechanisms in photobiology.		
NAS5-3546.....	Johns Hopkins University.....	10/68- 6/68	21,000
	Tunnel diode applications.		
NsG-58.....	Maryland, University of, H. LASTER, E. OPIK.....	2/68-10/68	55,000
(NGR-21-002-002)	Theoretical studies in atmospheric and space physics.		
NsG-70.....	Maryland, University of, R. W. KRAUSS.....	9/67- 4/68	38,112
(NGR-21-002-003)	Investigation of psychophysiology in controlled environments.	4/68- 3/69	55,000
NsG-189.....	Maryland, University of, J. V. BRADY.....	8/67- 7/70	22,536
	Research and development of fundamental performance information relevant to the behavior of organisms under conditions of space flight.		
NsG-398.....	Maryland, University of, W. C. RHEINBOLDT.....	3/68- 2/71	120,000
(NGR-21-002-008)	Multidisciplinary research on the application of high speed computers to space-related research problems.		
NsG-436.....	Maryland, University of, J. WEBER .....	7/68- 6/69	86,610
(NGR-21-002-010)	Study on theoretical and experimental research on gravitational radiation.		
NsG-615.....	Maryland, University of, W. C. ERICKSON.....	10/67- 9/68	65,000
(NGR-21-002-020)	Studies in the 11 meter range of radioastronomy.	10/67- 9/68	15,607
NsG-695.....	Maryland, University of, H. LASTER.....	6/68- 5/70	80,000
(NGR-21-002-033)	Theoretical & experimental studies in the space sciences, including consideration of rocket, probe, and satellites techniques.		
NGR-21-002-022....	Maryland, University of, C. O. ALLEY.....	10/67- 9/68	30,000
	Investigations of some basic physics of laser radiation.		
NGL-21-002-033....	Maryland, University of, H. LASTER.....	6/68- 5/71	122,000
	Theoretical and experimental studies in space science, including consideration of rocket, probe, and satellite techniques.		
NGR-21-002-057....	Maryland, University of, R. T. BETTINGER.....	11/67-10/68	50,000
	Ionospheric investigations with In Situ probes.		
NGR-21-002-060....	Maryland, University of, R. T. BETTINGER.....	11/67-10/68	50,479
	Analysis of satellite data for studies related to ionospheric plasma research.		
NGR-21-002-066....	Maryland, University of, J. A. EARL.....	2/68- 1/69	115,000
	A study of primary cosmic ray electrons, utilizing balloon-borne experiments.		
NGR-21-002-073....	Maryland, University of, H. R. GRIEM.....	3/68- 2/69	70,000
	Experimental and theoretical investigation of plasma radiation.		
NGR-21-002-096....	Maryland, University of, R. T. BETTINGER.....	6/68- 8/68	78,369
	Selected studies in atmospheric physics.		
NGR-21-002-167....	Maryland, University of, T. D. WILKERSON.....	1/68-12/68	50,408
	Optical absorption coefficients for uranium plasma.		
NGR-21-002-175....	Maryland, University of, W. J. BAILEY.....	5/68- 4/69	28,000
	Highly unsaturated sheet and ladder polymers with unusual electrical properties.		
NSR-21-002-077....	Maryland, University of, D. L. MATTHEWS.....	10/67-10/68	87,000
	Wide-range energy spectra of electrons in the disturbed and undisturbed ionosphere.		
NSR-21-002-147....	Maryland, University of, H. R. GRIEM.....	1/68- 5/68	5,500
	Second International Conference on Vacuum Ultra-Violet and X-Ray Spectroscopy of Laboratory and Astrophysical Plasmas.		
NAS5-9217.....	Maryland, University of.....	6/65- 6/69	8,000
	Data reduction services.		

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<b>MARYLAND—Continued</b>				
NAS5-11063	Maryland, University of	Experiment to analyze ions and electrons for Imp-H&J.	6/68- 6/69	\$55,000
NAS9-5886	Maryland, University of	Lunar gravimeter experiment for ALSEP.	4/66- 9/68	75,000
NAS9-7809	Maryland, University of	Laser ranging retroreflector.	5/68- 5/71	100,000
NsG-670 (NGR-21-012-001)	Woodstock College, M. J. BIELEFIELD	Theoretical and experimental studies in planetary and atmospheric physics.	9/67- 8/69	7,000
<b>MASSACHUSETTS:</b>				
N G R-22-004-018	Boston University, E. T. ANGELAKOS	Ultrasonic measurement of heart volume.	3/68- 2/69	25,918
NsG-375 (NGR-22-005-001)	Brandeis University, N. O. KAPLAN	A comparative study of the evaluation of enzymes and nucleic acids.	2/68- 1/69	39,781
N G R-22-005-025	Brandeis University, J. W. SENDER	Theoretical and analytical research of the attentional demand of complex perceptual tasks.	12/67-11/68	35,000
NsG-282 (NGR-22-007-005)	Harvard University, C. FRONDEL	Minerological and petrographic studies of meteorites.	1/68-12/68	20,000
NsG-438 (NGR-22-007-006)	Harvard University, L. GOLDBERG	Theoretical and experimental studies in ultraviolet solar physics.	2/68- 3/70	140,236
NsG-559 (NGR-22-007-012)	Harvard University, B. BUDIANSKY	Theoretical investigations in structural mechanics with particular emphasis on fracture mechanics and thin shell analysis.	7/67- 6/70	77,500
NsG-595 (NGR-22-007-019)	Harvard University, W. H. ABELMAN, L. E. EARLEY	Interrelations between systemic and regional blood volume, blood flow, and fluid and electrolyte balance.	7/68- 6/69	58,888
NsG-685 (NGR-22-007-021)	Harvard University, G. R. HUGUENIN	Long wavelength extension of solar radio burst observations.	12/67-10/68	119,712
N G R-22-007-053	Harvard University, W. A. BURGESS	Study of space cabin atmospheres.	7/68- 6/71	96,000
N G R-22-007-054	Harvard University, N. F. RAMSEY	Hydrogen maser studies of relativity.	9/67- 8/68	25,144
N G R-22-007-056	Harvard University, R. W. P. KING	Theoretical and experimental investigations of antennas and waves in plasma.	2/68- 9/68	5,000
NSR-22-007-067	Harvard University, L. GOLDBERG	Investigation of center-to-limb variations in the far ultraviolet solar spectrum by means of a spectral scanning spectrometer flown aboard an Aerobee-Hi rocket.	7/67- 1/68	71,166
N G R-22-007-068	Harvard University, A. E. BRYSON	Investigation of on-board computer techniques for space navigation.	1/68-12/68	50,000
N G R-22-007-069	Harvard University, E. S. BARGHOORN	Infrared absorption spectrophotometry of organic extractives from precambrian sediments.	6/68- 5/69	19,875
N G R-22-007-096	Harvard University, F. R. ERVIN	The estimation and prediction of mental alertness.	4/68- 3/69	44,478
N G R-22-007-101	Harvard University, D. M. HEGSTED	Factors in bone formation and bone loss.	6/68- 5/69 6/68- 5/71	20,000 20,000
N G R-22-007-117	Harvard University, N. BLOEMBERGEN	Investigation of the behavior of ultrashort light pulses of picosecond duration in optical media.	2/68- 1/69 2/68- 1/69	30,000 30,000
N G R-22-007-124	Harvard University, R. A. BAUER	Nonlinear optics and quantum electronics.	2/68- 8/68	24,790
N G R-22-007-126	Harvard University, P. S. PERSHAN	Raman scattering from solid materials.	11/67-10/68	30,000
NSR-22-007-115	Harvard University, L. GOLDBERG	Contract for scientific, technical and staff support to the Astronomy Missions Board.	10/67- 6/69	65,831

		<i>Agreement period</i>	<i>Amount</i>
MASSACHUSETTS—Continued			
NAS5-9274	Harvard University Pointed experiment for OSO-G Orbiting Solar Observatory.	6/66- 7/69 6/66- 7/69 6/66- 7/69	\$85,000 253,000 77,000
NAS9-8005	Harvard University Use of cyclotron for calibration.	5/68- 6/68	18,000
NAS9-8060	Harvard University Electron microscopy of returned lunar organic samples.	6/68-12/69	4,000
NGR-22-091-002	Holy Cross, College of the, R. C. GUNTER Investigation of the effect of space environment on replica gratings.	6/68- 5/69	4,500
NAS12-620	Lowell Technological Institute HF duct-propagation data reduction and analysis.	3/68- 3/69	27,000
NsG-107 (NGR-22-009-002)	Massachusetts Institute of Technology, T. B. SHERIDAN Study of the measurement and display of control information.	9/67- 9/68	46,560
NsG-117 (NGR-22-009-003)	Massachusetts Institute of Technology, N. J. GRANT Research on mechanisms of alloy strengthening by fine particle dispersions, with particular emphasis on selective reduction of non-refractory oxides, stability of metal-metal oxide systems, and solid solution matrices in metal-metal oxide alloys.	1/68- 1/69	84,390
NsG-211 (NGR-22-009-005)	Massachusetts Institute of Technology, K. BIEMANN Detection and identification of life-related matter by mass spectroscopy.	12/67- 1/69	75,000
NsG-234 (NGR-22-009-007)	Massachusetts Institute of Technology, J. REINTVES Investigation of radar techniques and devices suitable for the exploration of the planet Venus.	11/67-10/68	100,000
NsG-254 (NGR-22-009-010)	Massachusetts Institute of Technology, W. R. MARKEY Theoretical and experimental investigations to determine optimum guidance navigation and control system and instrumentation concepts and configuration for long term earth-orbiting and interplanetary spacecraft.	1/68-12/68	125,000
NsG-330 (NGR-22-009-012)	Massachusetts Institute of Technology, A. JAVIN Research on properties of optical and infrared masers.	10/67- 9/70	125,000
NsG-334 (NGR-22-009-013)	Massachusetts Institute of Technology, R. G. GALLAGER Research on techniques of communication in the space environment.	11/67-10/68	90,000
NsG-368 (NGR-22-009-014)	Massachusetts Institute of Technology, H. H. WOODSON, H. A. HAUS, J. R. MELCHER Theoretical and experimental investigations in electrohydrodynamics (EHD) and wave-type magnetohydrodynamics (MHD).	2/68- 1/69	55,700
NsG-386 (NGR-22-009-015)	Massachusetts Institute of Technology, H. S. BRIDGE Theoretical and experimental investigations of the interplanetary medium and in gamma-ray astronomy.	1/67-12/70	357,000
NsG-462 (NGR-22-009-018)	Massachusetts Institute of Technology, F. O. SCHMITT Multidisciplinary studies in the neurosciences.	7/68- 6/69	90,000
NsG-496	Massachusetts Institute of Technology, J. V. HARRINGTON Multidisciplinary research in space-related physical, engineering, social and life sciences.	12/67-11/70	300,000
NsG-577 (NGR-22-009-025)	Massachusetts Institute of Technology, L. R. YOUNG AND Y. T. LI Studies of human dynamic space orientation using techniques of control theory.	12/67-11/68	130,000
NGL-22-009-013	Massachusetts Institute of Technology, R. G. GALLAGER Techniques of communications in the space environment.	11/68-10/70	90,000
NGL-22-009-014	Massachusetts Institute of Technology, J. R. MELCHER Research in electrohydrodynamics.	2/68- 1/71	56,000
NGL-22-009-016	Massachusetts Institute of Technology, A. H. BARRETT Electromagnetic investigations of planetary and solar atmosphere and the lunar surface, including balloon-borne experiments and construction of laboratory prototype instrumentation.	5/68- 4/71	167,500

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MASSACHUSETTS—Continued			<i>Agreement period</i>	<i>Amount</i>
NGR-22-009-064...	Massachusetts Institute of Technology, J. C. JAMES.....		7/67- 6/68	\$30,914
	Radar investigations of solar coronal structures and motions at the El Campo, Texas, Radar Astronomy Facility.			
NGR-22-009-121...	Massachusetts Institute of Technology, L. TRILLING.....	11/67-10/68		17,101
	Theoretical investigation of the processes of energy and momentum exchange at a gas-solid boundary.			
NGR-22-009-125...	Massachusetts Institute of Technology, H. C. GATOS.....	4/68- 3/69		35,000
	Studies on the relationship between crystalline structure and superconductivity.			
NGR-22-009-156...	Massachusetts Institute of Technology, J. L. MEIRY, Y. T. LI.	1/68-12/68 1/69-12/70	25,082 25,000	
	Bio-physical evaluation of the human vestibular system.			
NGR-22-009-163...	Massachusetts Institute of Technology, R. P. RAFUSE.....	3/68- 2/69		60,000
	Investigation of solid state millimeter wave generation and amplification.			
NGR-22-009-167...	Massachusetts Institute of Technology, G. R. HARRISON..	3/68- 2/69		72,370
	Techniques for ruling improved large diffraction gratings.			
NGR-22-009-207...	Massachusetts Institute of Technology, W. R. MARKEY...	2/68- 1/69		69,843
	Research in trajectory analysis, guidance and control.			
NGR-22-009-229...	Massachusetts Institute of Technology, W. R. MARKEY...	9/67- 9/68		77,562
	Problems in aircraft navigation.			
NGR-22-009-229...	Massachusetts Institute of Technology, R. D. THORNTON.	1/68-12/68		34,920
	Thermal interactions in semiconductor devices.			
NGR-22-009-237...	Massachusetts Institute of Technology, C. H. PERRY.....	2/68- 1/69		38,000
	The study of optical properties and collective oscillations in new solid state materials as a function of temperature using infrared and Raman techniques.			
NGR-22-009-240...	Massachusetts Institute of Technology, A. JAVAN.....	12/67-11/68		40,000
	Spectroscope applications of optical and infrared masers.			
NGR-22-009-247...	Massachusetts Institute of Technology, D. KLEPPNER.....	1/68-12/68		25,000
	Study of a communications system for spacecraft relativity experiments.			
NGR-22-009-249...	Massachusetts Institute of Technology, G. B. BENEDEK..	2/68- 1/69		30,000
	High sensitivity magnets-optic modulator.			
NGR-22-009-272...	Massachusetts Institute of Technology, R. J. WURTMAN..	12/67-11/68		36,885
	Neuroendocrine rhythms: their control by environmental lighting.			
NGR-22-009-289...	Massachusetts Institute of Technology, H. S. BRIDGE.....	3/68- 2/70		95,350
	Program of data reduction and analysis of data obtained from Mariner/Venus plasma probe.			
NGR-22-009-303...	Massachusetts Institute of Technology, N. D. HAM.....	6/68- 5/69		82,991
	Investigation of rotor blade tip-vortex aerodynamics.			
NGR-22-009-304...	Massachusetts Institute of Technology, H. J. ZIMMERMAN.	12/67-11/70		250,000
	Research in the communication sciences.			
NGR-22-009-308...	Massachusetts Institute of Technology, H. L. TEUBER....	12/67-11/70		250,000
	Research in psychobiology.			
NGR-22-009-309...	Massachusetts Institute of Technology, Z. S. ZANNETOS...	3/68- 9/68		50,000
	Research in integrated planning and control systems.	9/68- 9/70		48,000
NGR-22-009-311...	Massachusetts Institute of Technology, J. P. VINTI.....	4/68- 3/69		19,930
	An improved representation of the earth's gravitational potential for use in geodetic studies.			
NGR-22-009-312...	Massachusetts Institute of Technology, L. R. YOUNG.....	3/68- 2/69		65,000
	Life support in unusual environments.			
NGR-22-009-337...	Massachusetts Institute of Technology, P. PENFIELD.....	5/68- 2/69		40,000
	Avalanche diode devices for the generation of coherent radiation.			
NGR-22-009-339...	Massachusetts Institute of Technology, E. A. WITNER.....	6/68- 5/69		58,635
	Investigation of concepts, methods of analysis and evaluation for containment/control of fragments from bursting turbine motors.			

		<i>Agreement period</i>	<i>Amount</i>
MASSACHUSETTS—Continued			
NASr-249.....	Massachusetts Institute of Technology, J. V. HARRINGTON.....	7/67- 6/68	\$185,000
(NSR-22-009-026)	Investigations directed to measuring electron densities and magnetic field distribution in the extended solar corona.		
NSR-22-009-129.....	Massachusetts Institute of Technology, H. BRADT.....	7/67- 6/68	173,332
	An X-ray astronomy experiment from a sounding rocket.		
NSR-22-009-138.....	Massachusetts Institute of Technology, L. L. SUTRO.....	10/67-10/68	150,000
	Automatic object recognition for extraterrestrial life.		
NSR-22-009-288.....	Massachusetts Institute of Technology, W. S. LEWELLEN.....	4/68- 3/70	40,558
	Study of fluid dynamics of gaseous nuclear rockets.		
NAS1-8423.....	Massachusetts Institute of Technology.....	6/68- 6/69	27,000
	An investigation of section characteristics of thin highly cambered aerodynamic surface.		
NAS2-3793.....	Massachusetts Institute of Technology.....	12/66- 6/68	22,000
	Pioneer A & B data analysis.		
NAS2-4919.....	Massachusetts Institute of Technology.....	6/68- 9/69	40,000
	Study on collisional energy transfer and chemical reaction in rapidly cooled gases.		
NAS5-2053.....	Massachusetts Institute of Technology.....	2/62- 6/68	45,000
	Instrumentation for plasma probe for earth geophysical observatory S-49 satellite.		
NAS5-3205.....	Massachusetts Institute of Technology.....	2/63- 3/69	29,000
	Gamma ray detector for the S-57 solar satellite.		
NAS5-11002.....	Massachusetts Institute of Technology.....	4/67- 6/68	162,000
	Inertial reference unit for OAO.		
NAS5-11062.....	Massachusetts Institute of Technology.....	5/68- 6/64	50,000
	Imp H&J plasma experiment.		
NAS5-11082.....	Massachusetts Institute of Technology.....	12/67- 8/70	132,000
	Studies and design for a rotating wheel experiment to provide a two-color survey of the positions and time variations of cosmic x-ray sources.		
NAS8-21451.....	Massachusetts Institute of Technology.....	6/68- 4/69	35,000
	Investigation of physical basis for observed statistical correlations between solar activity and changes in planetary configurations.		
NAS9-4065.....	Massachusetts Institute of Technology.....	1/68-12/68	8,399,406
	Apollo GM & LEM G & N systems design.		
NAS9-6823.....	Massachusetts Institute of Technology.....	4/67- 2/69	770,000
	Development & laboratory test of advanced manned mission guidance and control techniques.		
NAS9-7830.....	Massachusetts Institute of Technology.....	4/68- 7/69	160,000
	Radar and radiometric lunar surface studies.		
NAS9-8241.....	Massachusetts Institute of Technology.....	6/68-12/70	250,000
	Command module optical unit assembly.		
NAS9-8242.....	Massachusetts Institute of Technology.....	6/68-12/70	344,000
	Strapdown inertial reference unit.		
NAS12-101.....	Massachusetts Institute of Technology.....	2/66- 3/69	100,000
	Magnetic flux quantization and application research.		
NAS12-102.....	Massachusetts Institute of Technology.....	2/66- 8/68	10,000
	Application of analog-digital computer techniques to guidance and control problems.		
NAS12-569.....	Massachusetts Institute of Technology.....	6/67- 8/70	21,000
	Develop improved gyroscopes & specifications for procurement.	6/67- 8/70	2,000,000
NAS12-640.....	Massachusetts Institute of Technology.....	4/68- 6/69	55,000
	Study of plated wire stack design.		
NAS12-642.....	Massachusetts Institute of Technology.....	4/68- 4/69	65,000
	Design criteria monograph and survey.		
NAS12-658.....	Massachusetts Institute of Technology.....	4/68- 2/69	30,000
	NASA Star Mapper investigations.		
NAS12-668.....	Massachusetts Institute of Technology.....	5/68- 3/69	33,000
	Rel. test methods detect. gross leaks std. dev.		

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			<i>Agreement period</i>	<i>Amount</i>
MASSACHUSETTS—Continued				
NAS12-674	Massachusetts Institute of Technology	Seminar workshop in optical communications.	6/68-10/68	\$37,000
NAS12-679	Massachusetts Institute of Technology	Research on charged particle sources for implantation.	7/68- 8/69	25,000
N GR-22-010-018	University of Massachusetts, R. V. MANOPOLL	Pulse frequency modulation in control system.	2/68- 1/69	15,000
N GR-22-010-023	University of Massachusetts, W. M. IRVINE	Theoretical studies of diffuse reflection and transmission of radiation in planetary atmospheres.	6/68- 9/70	30,271
N GR-22-010-029	University of Massachusetts, J. F. BRANDTS	Low temperature studies on proteins and certain organisms.	5/68- 4/71	51,440
N GR-22-011-007	Northeastern University, W. B. NOWAK, B. L. COCHRAN	Reliable solid-state circuits.	12/67-11/68	40,000
N GR-22-011-024	Northeastern University, B. L. COCHRAN	Microminiaturized devices for bioastronautical monitoring or analysis.	2/68- 1/69 2/69- 1/71	50,000 50,000
N GR-22-011-025	Northeastern University, K. WEISS	Investigation of new systems for potential laser action.	3/68-11/68	18,000
NSR-22-011-036	Northeastern University, C. G. HOUTSMA	A program of NASA summer faculty fellowships.	1/68-12/68	64,885
NAS12-636	Northeastern University	A program to determine possible improvements in solar cells.	3/68- 7/68	5,000
N GR-22-012-006	Tufts University, D. H. SPODICK	Investigation of atraumatic techniques for monitoring cardiovascular conditioning.	4/68- 3/69	26,000
N GR-22-017-006	Worcester Polytechnic Institute, I. ZWIEBEL	Environmental control for prolonged space voyages-adsorption/desorption of nitrogen oxides.	5/68- 4/69	20,000
N GR-22-017-008	Worcester Polytechnic Institute, A. H. WEISS	Study of the techniques feasible for food synthesis aboard a spacecraft.	2/68- 1/69	28,611
MICHIGAN:				
NsG-2	Michigan, University of, F. J. BEUTLER		4/68- 3/69	24,914
(N GR-23-005-001)		Investigations in space communications theory, including topics related to random processes, filtering, telemetry, statistical methods, modulation, information transmission, and mathematical techniques.		
NsG-86	Michigan, University of, J. A. NICHOLLS		12/67- 3/69	18,000
(N GR-23-005-003)		Theoretical and experimental studies of the dynamics of reacting and charged particles in solid propellant rocket motor nozzles.		
NsG-115	Michigan, University of, C. KIKUCHI		12/67-11/68	34,673
(N GR-23-005-004)		Investigation of the electromagnetic properties of materials for application to masers, lasers, and other solid state devices.		
NsG-344	Michigan, University of, S. K. CLARK		1/68-12/68	38,220
(N GR-23-005-010)		Structural analysis of aircraft tires.		
NsG-696	Michigan, University of, J. E. ROWE		10/67- 9/68	40,000
(N GR-23-005-062)		Nonlinear interaction phenomena in the ionosphere.		
NGL-23-005-005	Michigan, University of, J. W. FREEMAN	To determine the scope and cause of notch sensitivity of materials under creep-rupture conditions.	4/69- 3/71	43,937
N GR-23-005-183	Michigan, University of, G. I. HADDAD	Frequency multiplication in high-energy electron beams.	10/68- 9/70	75,000
N GR-23-005-185	Michigan, University of, J. R. P. FRENCH	Investigate the application of new bioelectronics to cardiovascular stresses.	3/68- 6/68	17,983
N GR-23-005-201	Michigan, University of, R. VON BAUMGARTEN	Stimulated weightlessness in fish and neurophysiological studies on memory in lower animals.	2/68- 1/69	40,000

## APPENDIX R

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		<i>Agreement period</i>	<i>Amount</i>
<b>MICHIGAN:</b>			
NGR-23-005-275	Michigan, University of, O. C. MOHLER.....	4/68- 3/69	\$55,000
	Part I—Support for continuation of the solar research program of the McMath-Hulbert Observatory. Part II—Improvement of phot heliographic telescope.		
NGR-23-005-285	Michigan, University of, B. ARDEN.....	3/68- 6/68	3,333
	Digital computer simulation.		
NASr-54(03)	Michigan, University of, F. L. BARTMAN.....	10/67- 9/68	370,000
(NSR-23-005-903)	Development of laboratory and flight experimental techniques directed toward obtaining data to be used in interpreting satellite (TIROS and NIMB-US) radiation measurements.		
NASr-54(05)	Michigan, University of, L. M. JONES.....	7/67- 8/68	300,000
(NSR-23-005-905)	Survey measurements of upper air structure.		
NASr-54(06)	Michigan, University of, R. W. PEW.....	7/67- 6/68	140,700
(NSR-23-005-906)	Development of on-line man-machine system performance measurement and display techniques.		
NASr-54(09)	Michigan, University of, R. TESKE.....	3/66- 6/66	1,400
	Conduct a design study of a visual coronagraph suitable for operation in a manned earth-orbiting vehicle.		
NASr-54(11)	Michigan, University of, L. M. JONES.....	1/68- 6/68	30,435
(NSR-23-005-911)	Develop grenade and sphere instrumentation.		
NAS5-2051	Michigan, University of.....	2/62-6/68	25,000
	Instrumentation & support for experiment in radio astronomy for Earth geophysical observatory S-49 satellite.		
NAS5-3098	Michigan, University of.....	11/62-12/68	56,000
	Instrumentation & support for neutral particle & ion composition experiment for S-50 POGO satellite.	11/62-12/68	50,000
NAS5-3335	Michigan, University of.....	6/63- 4/69	311,000
	Atmospheric temperature and density measurement of the Earth's atmosphere.		
NAS5-9099	Michigan, University of.....	12/64-12/68	43,000
	Instrumentation for radio astronomy experiment for the OGO program mission.		
NAS5-9113	Michigan, University of.....	12/64- 3/69	300,000
	Study of gas dynamics in an enclosed moving ion source.	12/64- 3/69	77,000
		12/64- 3/69	100,000
		12/64- 3/69	5,000
NAS5-9306	Michigan, University of.....	3/66- 6/68	10,000
	Fabrication, instrumentation for electron temperature and density probe experiment for orbiting geophysical observatory Mission F (OGO-F).	3/66- 6/68	12,000
NAS5-9328	Michigan, University of.....	4/66- 6/68	37,000
	Neutral atmospheric composition experiment for orbiting geophysical observatory Mission F (OGO-F).		
NAS8-20357	Michigan, University of.....	2/66- 3/69	63,000
	High altitude environment measurement study.		
NASr-175	Wayne State University, H. STILLWELL.....	12/67- 6/68	30,000
(NSR-23-006-003)	A program to accelerate the industrial application of aerospace related technology.		
NGR-23-010-004	Western Michigan University, R. R. HUTCHINSON.....	2/68- 1/69	10,000
	Effects of noncontingent reinforcement and punishment.		
<b>MINNESOTA:</b>			
NsG-281	Minnesota, University of, J. R. WINCKLER, E. P. NEY ...	7/67- 6/69	143,000
(NGR-24-005-008)	Studies of cosmic rays, astrophysics, and energetic electrons in space, including balloon and rocket flight experiments.		
NsG-517	Minnesota, University of, G. HALBERG.....	2/68- 8/68	45,000
(NGR-24-005-006)	Ground-based studies on internal and external synchronization or desynchronization of mammalian rhythms with special reference to the mouse.		

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		<i>Agreement period</i>	<i>Amount</i>
MINNESOTA—Continued			
NGL-24-005-008	Minnesota, University of, J. R. WINCKLER	7/68- 6/70	\$267,000
	A research program in the area of cosmic rays, astrophysics and energetic particles in space.		
NGR-24-005-050	Minnesota, University of, W. R. WEBBER, C. S. WADDINGTON.	2/68-12/68 4/68- 3/69	50,000 73,149
	Measurement of the gamma ray flux of various celestial point sources from high altitude balloons.		
NGR-24-005-070	Minnesota, University of, C. C. HSIAO	5/68- 4/69	19,842
	Theoretical and experimental investigation of the mechanical strength of solids.		
NGR-24-005-095	Minnesota, University of, R. PLUNKETT	6/68- 6/69	10,000
	Investigation of optimum structural design under dynamical loading.		
NGL-24-005-160	Minnesota, University of, R. G. BOND	6/68- 5/71	400,000
	To cover activities in the environmental health area (environmental microbiology) relating to planetary quarantine.		
NSR-24-005-062	Minnesota, University of, W. J. LUYTEN, J. E. CARROLL	11/66- 6/68	118,022
	Automatic proper motion survey of the stellar system.		
NSR-24-005-093	Minnesota, University of, P. KELLOGG	7/67- 6/68	14,939
	Design and construction of prototype instruments for a sounding rocket investigation of electrostatic waves in the magnetosphere.		
NAS2-2738	Minnesota, University of	12/64- 6/68	28,000
	Continuation of biosatellite project experiment P-1093—Spectra of Metabolic Rhythms in Rats.		
NAS2-3360	Minnesota, University of	12/65-11/65	32,000
	Cosmic ray experiment for Pioneer Project.		
NAS3-7904	Minnesota, University of	6/65- 3/69	39,000
	Theory of film cooling for turbine blades.		
NAS5-1386	Minnesota, University of	9/61- 7/68	47,000
	Zodiacal light monitoring.		
NAS5-2071	Minnesota, University of	8/62- 6/68	29,000
	Instrumentation & support for experiment in particle flux & spectra study in radiation belt for S-49 satellite.		
NAS5-11060	Minnesota, University of	3/68-12/70	208,000
	Electromagnetic fields experiment for IMP-I.		
NAS9-4500	Minnesota, University of	6/65- 7/69	84,000
	Evaluation & development of an impedance plethysmographic system to measure cardiac output.		
NAS9-8093	Minnesota, University of	6/68-12/69	33,000
	Measure the elemental and isotopic abundance of he, ne, ar, kr, and xe by mass spectrometer.		
MISSISSIPPI:			
NAS8-21377	Mississippi State University	5/68- 5/69	34,000
	Investigation in adaptive sampling, and optimum sampling procedures.		
NGR-25-002-015	Mississippi, University of, H. T. MILHORN	6/68- 5/69	32,118
	Conceptual idea of digital computer model of human respiratory system.		
MISSOURI:			
NGR-26-004-003	Missouri, University of (Columbia), WARD J. HAAS	2/68- 1/71	50,000
	Multidisciplinary research in space-related physical, engineering and life sciences.		
NGR-26-004-011	Missouri, University of (Columbia), C. W. GEHRKE	9/67- 8/68	13,000
	Gas chromatographic techniques for the identification and study of nucleosides.		
NGR-26-001-006	Missouri, University of (Kansas City), P. J. BRYANT	6/68- 8/69	42,870
	Cohesion and binding energy relating to cold welding problems.		
NGR-26-003-026	Missouri, University of (Rolla), R. D. RECHTER	6/68- 5/69	35,552
	A study of the fluctuating pressure field in regions of indirect flow separation of supersonic speeds.		

		<i>Agreement period</i>	<i>Amount</i>
<b>MISSOURI—Continued</b>			
NGR-26-003-037	Missouri, University of (Rolla), E. C. BERTNOLLI.....	6/68- 5/69	\$9,942
	Research on the impulse techniques for testing microcircuits.		
NAS12-692	Missouri, University of (Columbia).....	3/68- 7/69	12,000
	Fault diagnosis for SSA electronic systems.		
NsG-185	Washington University (St. Louis), J. KLARMANN, M. W. FRIEDLANDER.	2/68- 1/69	59,991
(NGR-26-008-001)	Investigation of primary cosmic radiation using spark chambers and nuclear photographic emulsions.		
NGL-26-008-006	Washington University (St. Louis).....	3/68- 2/71	100,000
	University-wide research program in space related sciences and technology.		
NGR-26-008-042	Washington University (St. Louis), J. KLARMANN.....	6/68- 5/69	120,741
	Gamma ray experiment based on spark chambers and nuclear emulsions.		
NGR-26-008-043	Washington University (St. Louis), R. M. WALKER.....	9/67- 8/68	25,000
	Study of extremely heavy cosmic rays.		
NAS2-4151	Washington University (St. Louis).....	1/67- 8/68	2,000
	Studying of lifting rotor vibrations.		
NAS9-8165	Washington University (St. Louis).....	1/67- 7/69	27,000
	Measurement and analysis of the effect of cosmic radiation on returned lunar samples.		
NAS9-8352	Washington University (St. Louis).....	6/68-10/69	127,000
	Study for the development and test of a plastic nuclear emulsion heavy ray detection system.		
<b>MONTANA:</b>			
NGL-27-001-001	Montana State University.....	7/68- 6/71	100,000
	Multidisciplinary research in space science and engineering.		
<b>NEVADA:</b>			
NAS9-7779	Nevada, University of.....	2/68- 8/68	50,000
	Geologic around truth studies.		
<b>NEW HAMPSHIRE:</b>			
NGR-30-001-011	Dartmouth College, B. U. O. SONNERUP.....	10/67-10/68	20,000
	Study of the structure of the magnetopause, utilizing satellite-obtained magnetometer data.		
NSR-30-001-018	Dartmouth College, T. LAASPERE.....	4/68- 3/69	33,915
	Support of an existing network of Whistler ground stations to yield data for comparison with data from OGO-II, -D, and -F.		
NAS5-3092	Dartmouth College.....	11/62-12/68	12,000
	Instrumentation and support for very low frequency OGO experiments.		
NAS5-9305	Dartmouth College.....	3/66- 6/68	65,000
	Whistler-mode waves experiment for the Orbiting Geophysical Observatory, Mission F (OGO-F).		
NsG-624	New Hampshire, University of, R. A. KAUFMAN.....	10/67- 9/69	31,195
(NGR-30-002-010)	Studies and analyses of the magnetospheric boundary, the geomagnetic tail, and correlation with trapped particle measurements in the outer magnetosphere.		
NGR-30-002-018	New Hampshire, University of, E. L. CHUFP.....	2/68- 1/69	13,000
	Investigation of energy levels in foil excited atomic beams.		
NGR-30-002-021	New Hampshire, University of, E. L. CHUFP.....	2/68- 1/69	100,000
	Investigation and development of techniques for solar neutron and gamma ray detection.		
NASR-164	New Hampshire, University of, J. A. LOCKWOOD.....	9/67- 9/68	130,000
(NSR-30-002-003)	Measurement of neutron intensity in space.		
NAS5-9313	New Hampshire, University of.....	3/66- 6/68	67,000
	Neutron monitor experiment for the orbiting geophysical observatory, Mission F (OGO-F).		
NAS5-11054	New Hampshire, University of.....	8/67- 9/70	100,000
	Study and design effort for rotating wheel experiment OSO-H.		

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		<i>Agreement period</i>	<i>Amount</i>
<b>NEW JERSEY:</b>			
NAS8-21286.....	Newark College of Engineering.....	4/68- 4/69	\$23,000
	Chemical and structural analysis of second breakdown.		
NsG-69.....	Princeton University, M. SCHWARZSCHILD.....	2/68- 6/68	400,000
(NGR-31-001-001)	Stratoscope II high altitude balloon telescope program.	2/68- 5/68	100,000
NsG-685.....	Princeton University, W. R. SCHOWALTER.....	7/68- 6/69	15,000
(NGR-31-001-025)	Constitutive equations for nonviscometric flows.		
NGL-31-001-005.....	Princeton University, R. G. JAHN.....	10/68- 9/70	150,000
	Studies of pulsed electromagnetic gas accelerator.		
NGL-31-001-007.....	Princeton University, L. SPITZER.....	4/68- 3/71	134,000
	Astrophysical ultraviolet studies.		
NGR-31-001-044.....	Princeton University, L. SPITZER.....	11/67- 6/68	20,000
	Design study of manned orbiting telescope for an extended Apollo system.		
NGR-31-001-074.....	Princeton University, C. L. MELLOR.....	10/67- 9/68	48,010
	Investigation of turbulent boundary layers with suction, cross flows and wall.		
NGR-31-001-103.....	Princeton University, S. H. LAM.....	7/67- 8/68	67,000
	Studies in ionospheric aerodynamics.		
NGR-31-001-109.....	Princeton University, M. SUMMERFIELD.....	10/67- 9/68	79,478
	Design principles for predicting the ignition performance of solid propellant rocket motors.		
NGR-31-001-119.....	Princeton University, W. D. HAYES.....	10/67- 9/68	22,790
	Theoretical problems connected with sonic boom.		
NGR-31-001-124.....	Princeton University, E. H. DOWELL.....	3/68- 2/69	27,034
	Theoretical investigation on panel flutter criteria for launch vehicles.		
NGR-31-001-129.....	Princeton University, I. GLASSMAN.....	4/68 9/68	30,000
	Combustion of metals.		
NGR-31-001-132.....	Princeton University, A. W. LO.....	7/68- 6/69	9,970
	Impulse techniques for testing digital microcircuits.		
NASr-217.....	Princeton University, D. T. HARRELL.....	2/68- 1/69	275,000
(NSR-31-001-018)	Combustion instability in liquid propellant rocket motors.		
NASr-223.....	Princeton University, C. PITTEDRICH.....	10/67- 9/68	72,485
(NSR-31-001-034)	Experimental analysis of circadian rhythms under terrestrial conditions.		
NASr-231.....	Princeton University, J. P. LAYTON.....	10/66- 9/68	10,000
(NSR-31-001-029)	Research on propulsion system and mission analysis pertaining to advanced launch vehicle technology.		
NSR-31-001-127.....	Princeton University, J. L. LOWRANCE.....	6/68- 5/69	100,000
	Evaluation and development of television tubes for space astronomy.		
NAS1-7022.....	Princeton University.....	1/67- 5/69	30,000
	Evaluation of the variables in the mechanical spectroscopy of pyrolyses.		
NAS5-1810.....	Princeton University.....	6/62-12/68	110,000
	Design, develop, fabricate & test orbiting astronomical observatory experiment.	6/62-12/68	200,000
NAS9-7897.....	Princeton University.....	6/68-10/69	62,000
	Determine pyroxene content by x-ray and optical methods.		
NGR-31-003-014.....	Stevens Institute of Technology, R. F. McALEVY.....	10/67-10/68	47,000
	Investigation of the flame spreading over the surface of ignited solid propellants.		
NGR-31-003-020.....	Stevens Institute of Technology, H. MEISSNER.....	4/68- 3/69	18,900
	Proximity effects between superconducting and normal metals.		
NGR-31-003-043.....	Stevens Institute of Technology, J. G. DAUNT.....	6/67-11/68	25,000
	Investigation of desorption cooling.		
NGR-31-003-050.....	Stevens Institute of Technology, G. J. HERSKOWITZ.....	1/68-12/68	15,077
	Microcircuit models and diagnostic techniques for environmental failure mode prediction.		

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NEW JERSEY—Continued			
NGR-31-003-066	Stevens Institute of Technology, E. C. NEY	6/68- 5/69	\$9,993
	An investigation to develop computer techniques for fault identification in multi-terminal networks.		
NSR-31-003-016	Stevens Institute of Technology, I. R. EHRLICH	11/67- 8/68	24,000
	Theoretical and experimental studies of aircraft tire hydroplaning.		
NAS12-654	Stevens Institute of Technology	4/68- 8/69	12,000
	Analysis of nonlinear circuits by computer.		
NEW MEXICO:			
NsG-142	New Mexico State University, C. W. TOMBOUGH	4/68- 4/71	120,000
(NGR-32-003-001)	Photographic, photoelectric and spectrographic observations and studies of the planets.		
NGR-32-003-027	New Mexico State University, J. E. WEISS	9/67- 8/70	50,000
	Multidisciplinary research program in space science and engineering.		
NGR-32-003-037	New Mexico State University, F. F. CARDEN	2/65- 5/70	50,801
	Study of video processing in low signal to noise environments.		
NAS5-10427	New Mexico State University	6/67- 6/69	50,200
	Telemetry services and research and development.	6/67- 6/69	20,000
		6/67- 6/69	470,000
NAS5-10554	New Mexico State University	8/67- 6/69	62,000
	Data reduction.		
NAS9-95304	New Mexico State University	4/68- 5/69	18,000
	Study of moisture in compressed gases.		
NGR-32-004-026	New Mexico, University of, C. G. RICHARDS	11/67-10/68	33,416
	Numerical study of the flow in the vortex rate sensor.		
NGR-32-004-036	New Mexico, University of, A. W. PETERSON	4/68- 3/69	40,000
	Thermal emission from interplanetary dust.		
NGR-32-004-042	New Mexico, University of, W. W. GRANDEMANN	2/68- 1/71	300,000
	The proof-of-concept approach to the design and management of public policy programs.		
NAS5-9275	New Mexico, University of	12/65- 6/68	81,000
	Experiment for OSO-G entitled "High Energy Neutron Flux in Space".		
NAS5-0314	New Mexico, University of	3/66- 6/68	66,000
	Solar ultraviolet energy survey experiment for the Orbitina Geophysical Observatories Program. OGO-F Mission.	3/66- 6/66	15,000
		3/66- 6/68	19,000
NsG-279	New Mexico, University of, W. W. GRANDEMANN	1/68-12/68	17,323
(NGR-32-004-002)	Research on Hall effect for low voltage, high current DC and AC conversion.		
NEW YORK:			
NsG-197	New York, City College of, H. LUSTIG	7/67- 6/68	32,000
(NGR-33-013-002)	Satellite motion near an oblate spheroid and interatomic potentials of binary systems.		
NGR-33-013-009	New York, City College of, R. SHINNER	5/63- 4/69	20,000
	Study of atomization of viscoelastic fluids.		
NGR-33-013-034	New York, City College of, C. M. TCHEN	4/63- 3/71	32,000
	Investigations of electromagnetics and statistical dynamics as applied to plasma propulsion.		
NGR-33-007-061	Technology, Clarkson College of, C. W. HAINES	2/68- 5/69	12,160
	Application of optimal control theory to the design of an autopilot for reduction of acceleration inputs to an aircraft in turbulent air.		
NsG-360	Columbia University, R. Novick	1/68-12-68	58,000
(NGR-33-008-009)	Theoretical and experimental investigations of helium and lithium atoms and ions with emphasis on excited energy levels and the mechanism of energy transfer from metastable states.		

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NEW YORK—Continued			
NsG-445	Columbia University, H. M. FOLEY, R. NOVICK, L. WOLNIER, P. W. GAST	9/67- 8/68	\$199,253
(N G R -33-008-012)	Theoretical and analytical studies of planetary and stellar structure, evolution and dynamical processes; and applicability of geophysical methods to such studies.		
N G R -33-008-102	Columbia University, E. J. OTT Research in x-ray astronomy.	1/68-12/68	75,000
N S R -33-008-069	Columbia University, W. A. OWENS Summer institute in space physics and in space science and engineering.	12/65-12/68	48,640
NAS9-5957	Columbia University Passive seismic experiment for ALSEP.	5/66- 6/69	100,000
		5/66- 6/69	291,000
NAS9-6037	Columbia University Heat flow experiment for ALSEP.	4/67- 6/69	6,000
		6/66- 6/69	161,000
NAS9-7890	Columbia University Measurement of physical properties on returned lunar samples.	5/68-10/69	25,000
NAS9-7895	Columbia University Determine concentration of the alkali alkaline earth and lanthanide elements by mass spectroscopy.	6/68-10/69	60,000
N G L -33-010-005	Cornell University, T. GOLD Lunar surface and solar systems studies.	11/67-10/70	40,000
N G R -33-010-029	Cornell University, L. H. GERMER Adsorption and chemical reactions of atoms and molecules on the surface of crystals.	5/68- 4/69	20,000
N G R -33-010-047	Cornell University, P. R. MCISAAC Advanced concepts of microwave power amplification and generation utilizing linear beam devices.	11/68-10/70	30,000
N G R -33-010-051	Cornell University, C. L. TANG Theoretical and experimental studies of the ionized rare gas lasers.	2/68- 1/69	25,000
N G R -33-010-057	Cornell University, F. K. MOORE Sonic boom phenomena.	9/69- 8/71	24,000
N G R -33-010-064	Cornell University, T. A. COOL Molecular energy transfer by fluid mixing.	1/68-12/70	40,000
N G R -33-010-071	Cornell University, H. N. McMANUS Graduate engineering design program—Phase II.	7/68- 6/70	29,637
N S R -33-010-026	Cornell University, M. HARWIT Astronomical observations in the far infrared.	11/67-11/68	175,171
NAS9-8018	Cornell University Preparation of equipment and techniques for lunar sample analysis.	6/68-12/69	38,000
N G R -33-012-009	Fordham University, W. C. CORNING Central nervous system mechanisms and information processing in limulus.	7/68- 6/70	6,548
N S R -33-012-006	Fordham University, J. KUBIS Time and motion study on astronauts' ground-based and inflight task performance.	6/67- 6/68	6,000
N G R -33-015-061	New York, State University of (Buffalo), R. G. HUNT Study of extra-contractual influences in government contracting.	9/68- 5/69	40,000
N G R -33-015-082	New York, State University of (Stony Brook), O. A. SCHAEFFER Study of high energy and relativistic astrophysics.	4/68- 3/69	30,000
N S R -33-015-077	New York, State University of (Stony Brook), O. A. SCHAEFFER A summer program in observational and theoretical space sciences.	1/68-12/68	29,150
N G R -33-015-016	New York, State University of (Stony Brook), J. DANIELLI Multidisciplinary research in theoretical biology.	1/68-12/68	100,000

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NEW YORK--Continued			
NGR-33-015-035..	New York, State University of (Stony Brook), L. L. SEIGLE.	6/68- 5/69	\$23,885
	Investigation of thermodynamic properties of interstitial elements in the refractory metals.		
NGR-33-015-036..	New York, State University of (Stony Brook), Y. H. KOA	12/67-11/68	50,000
	Research in infrared astronomy.		
NsG-76.....	New York University, R. C. SAHNI	5/68- 4/69	60,000
(NGR-33-016-003)	Theoretical research in the fields of molecular quantum mechanics and transport properties of diatomic molecules.		
NsG-499.....	New York University, J. E. MILLER	2/68- 2/69	47,938
(NGR-33-016-013)	Theoretical research on the properties of the atmospheres of the Earth and other planets and on the atmospheric effects of solar activity.		
NGR-33-016-067..	New York University, J. R. RAGAZZINI	9/67- 8/70	100,000
	Multidisciplinary research in space science and engineering.		
NGR-33-016-128..	New York University, L. ARNOLD	12/67-11/68	50,000
	An investigation of jet noise and its abatement.		
NGR-33-016-102..	New York University School of Medicine, J. Post	7/68- 6/69	24,140
	Biological effects of radiation: Metabolic and replication kinetics alterations.		
NGR-33-016-131..	New York University, A. FERRI	3/68- 2/69	149,780
	Hypersonic engine airplane integration.		
NASr-183.....	New York University, L. DAUERMAN	1/68- 1/69	65,000
	Investigation of the chemical kinetics of reactions that occur in advanced high energy propellant combustion.		
NsG-409.....	Brooklyn, Polytechnic Institute of, M. H. BLOOM	11/67-11/68	25,000
(NGR-33-006-002)	Theoretical and experimental investigations in the electromagnetic, radiative and thermodynamic properties of ionized flows of gases, and in plasma boundary conditions at conducting and non-conducting walls.		
NsG-589.....	Brooklyn, Polytechnic Institute of, H. J. JURETSCHKE	5/68- 4/69	35,000
(NGR-33-006-007)	Theoretical and experimental studies of electronic properties of thin films.		
NGR-33-006-040..	Brooklyn, Polytechnic Institute of, M. SCHWARTZ	1/68-12/68	30,000
	Digital techniques for signal processing.		
NGR-33-006-042..	Brooklyn, Polytechnic Institute of, J. J. BONGIORNO	3/68- 2/69	24,543
	Minimum sensitivity design of attitude control systems.		
NGR-33-006-047..	Brooklyn, Polytechnic Institute of, S. GROSS	4/68- 3/69	14,994
	Investigation of diffraction by planetary atmospheres.		
NsG-663.....	Rensselaer Polytechnic Institute, J. B. HUDSON	10/67- 9/68	35,000
(NGR-33-018-017)	Spatial nucleation and crystal growth.		
NGR-33-018-053..	Rensselaer Polytechnic Institute, F. A. WHITE	10/67- 9/70	72,000
	Techniques for increasing the sensitivity of mass spectrometric gas analyses, utilizing ion factors.		
NGR-33-018-075..	Rensselaer Polytechnic Institute, E. HOLT	9/67- 8/69	20,000
	Non-equilibrium properties of magnetoplasmas.		
NGR-33-018-086..	Rensselaer Polytechnic Institute, P. HARTECK	5/68- 4/69	30,000
	A study of the effect of surfaces on oxygen atom recombination at low pressures.		
NAS8-21131.....	Rensselaer Polytechnic Institute	5/67-11/68	19,000
	Advanced conventional control.		
NASr-14.....	Rochester, University of, R. E. HOPKINS	12/67-11/68	62,330
(NSR-33-019-007)	Studies and investigations of optical systems.		
NsG-483.....	Syracuse University, D. V. KELLER	6/68- 5/69	27,825
(NGR-33-022-004)	Theoretical and experimental studies of adhesion of metals in high vacuum.		

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NEW YORK—Continued			
N G R - 33-022-082...	Syracuse University, D. S. DOSANH.....	6/68- 5/69	\$35,000
	Noise generation from interacting high speed axisymmetric jet flows.		
N G R - 33-022-090...	Syracuse University, J. C. HONEY.....	1/68-12/70	500,000
	Multidisciplinary studies in management and development programs in the public sector.		
N G R - 33-022-091...	Syracuse University, J. J. ZWISLOCKI.....	5/68- 4/69	15,574
	Development of an acoustic coupler for earphone calibration.		
N G R - 33-022-032...	Syracuse University, H. W. LIU.....	9/67- 8/68	27,883
	Fatigue crack propagation and strains within plastic zone.		
N G R - 33-023-018...	Yeshiva University, A. G. W. CAMERON.....	7/67- 6/68	75,000
	Research in space physics.		
NORTH CAROLINA:			
N s G - 152.....	Duke University, T. G. WILSON.....	2/68- 1/69	69,900
	(N G R - 34-001-001) Research on satellite electrical power conversion systems and circuit protection.		
N G L - 34-001-001...	Duke University, T. G. WILSON.....	2/69- 1/71	70,000
	Research on spacecraft electrical power conversion.		
N G R - 34-001-005...	Duke University, J. B. CHADDOCK.....	2/68- 1/71	100,000
	Multidisciplinary space-related research in the physical, engineering, and life sciences.		
N G R - 34-001-019...	Duke University, K. SCHMIDT-KOENIG.....	9/67- 8/68	21,369
	Experimental analysis of animal orientation and related functions.		
N A S 5 - 3815.....	Duke University.....	5/64-12/68	48,000
	Spacecraft telemetry system.		
N A S 1 - 7265.....	North Carolina State University (Raleigh).....	4/68- 5/69	50,000
	Assembling previous research results applicable to present-day, personal-type aircraft.		
N G R - 34-002-017...	North Carolina State University (Raleigh), W. H. BENNETT.....	12/67-11/68	17,403
	Transverse instabilities of magnetically self-focusing streams in plasmas.		
N G R - 34-002-032...	North Carolina State University (Raleigh), H. SAGAN....	9/67- 9/69	40,833
	Mathematical theory of optimal control.		
N G R - 34-002-047...	North Carolina State University (Raleigh), F. J. TISCHER.....	7/68- 6/71	49,200
	Study of rectangular-guide-like structures for millimeter wave transmission.	7/68- 6/71	50,000
N G R - 34-002-048...	North Carolina State University (Raleigh), H. A. HASSAN.....	2/68- 1/70	10,000
	Theoretical investigation of surface interaction effects on plasma accelerators and MHD power generators.		
N G R - 34-002-061...	North Carolina State University (Raleigh), L. A. JONES....	6/68- 5/71	77,500
	Analysis of the total environment of closed ecological systems.		
N G R - 34-002-072...	North Carolina State University (Raleigh), L. A. JONES....	6/68- 8/69	14,176
	Studies in the oxidation and reduction of aromatic nitro compounds.		
N G R - 34-002-073...	North Carolina State University (Raleigh), M. A. LITTLE-JOHN.....	3/68- 2/69	15,000
	The piezoresistive effect in electron irradiated silicon and its application to the improvement of semiconductor strain gages.		
N G R - 34-003-021...	North Carolina, University of, H. A. TYROLER.....	7/68- 6/69	45,000
	Study and assessment of community health factors near major aerospace installations.		
OHIO:			
N A S 2 - 3528.....	Bowling Green University.....	2/66-12/64	85,000
	Biosatellite project experiment P-1160: Possible effects of zero-gravity on radiation induced somatic damage.		

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OHIO—Continued			
NsG-639	Case Institute of Technology J. F. WALLACE (NGR-36-003-033)	5/68- 4/69	\$14,964
	An experimental investigation on modified eutectic alloys for high temperature service, with emphasis on problems of remote manipulations.		
NsG-728	Case Institute of Technology, B. RESWICK AND H. MERG- LER (NGR-36-003-042)	8/67- 7/68	59,897
	Investigation of control in man-machine systems.		
NGR-36-003-054	Case Institute of Technology, J. L. KOENIG Mechanical properties of polyethylene terephthalate under selected conditions and methods of preparation.	5/68- 4/69	50,000
NGR-36-003-067	Case Institute of Technology, A. KUPER Impurities and interface states in the SiO <sub>2</sub> /Si systems.	9/67- 8/68	26,737
NGR-36-003-079	Case Institute of Technology, W. H. KO Investigation of implantable multichannel biotelemetry systems.	3/68- 2/69	48,225
NGR-36-003-088	Case Institute of Technology, S. OSTRACH Investigation of biological fluid mechanics.	10/67- 9/70	24,000
NGR-36-003-094	Case Institute of Technology, L. LEONARD The effect of deformation on dispersion.	9/67- 9/68	23,750
NGR-36-003-100	Case Institute of Technology, A. R. COOPER Diffusive mixing as a tool for confirming the origin of tektites.	4/68- 3/69	20,000
NSR-36-003-051	Case Institute of Technology, I. GREBER, W. T. OLSON A summer institute in space-related engineering.	4/68- 3/69	41,700
NGR-36-003-139	Case Western Reserve University, E. RESHOTKO Investigation of fundamental phenomena relevant to the design of small pumps.	7/68- 6/70	49,945
NGR-36-004-008	Cincinnati, University of, TI YI LI, H. OQURO Investigation of heat transfer and instability in two phase flow phenomena.	12/67-11/68	71,074
NGR-36-004-014	Cincinnati, University of, R. P. HARRINGTON Multidisciplinary space-related research in the physical, engineering, life and social sciences.	1/68-12/71	50,000
NsG-463 (NGR-36-007-001)	Kent State University, J. W. REED Theoretical and experimental studies of the magnetic and molecular properties of selected compounds, using neutron diffraction techniques.	7/68- 6/70	47,773
NsG-74 (NGR-36-008-002)	Ohio State University, C. A. LEVIS Investigations and studies of detection and receiver techniques, at millimeter and submillimeter wavelengths.	10/67- 9/68	25,000
NsG-295 (NGR-36-008-004)	Ohio State University, H. S. WEISS Biological effects of prolonged exposure of small mammals to closed gaseous environments low in or free of nitrogen.	3/68- 2/69	31,986
NGR-36-008-106	Ohio State University, R. M. NEREM Combined conductive and radiative end wall heat transfer behind reflected shock waves in air and nitrogen.	3/68- 2/69	15,000
NSR-36-008-108	Ohio State University, H. V. ELLINGTON Critical analysis and review of state-of-the-art in space medicine.	6/68- 6/69	174,411
NAS5-11543	Ohio State University Theoretical study of V antenna characteristics of the ATS-E Radio Astronomy Experiment.	5/68-11/68	21,000
NAS8-21317	Ohio State University Preparation of pigments for space-stable thermal control coatings.	6/68- 6/69	20,000
NAS9-6910	Ohio State University Effect of oxygen on red cells.	4/67- 6/69	20,000
NAS9-8379	Ohio State University MSF experiment definition.	6/68- 7/70	32,000
NSR-36-023-001	Wooster Polytechnic Institute, R. L. ROSHALT A study of the administrative history of NASA.	11/67- 6/68	1,559

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<b>OKLAHOMA:</b>				
NsG-609.....	Oklahoma State University, V. S. HANEMAN.....	(NGR-37-002-011)	10/67- 9/70	\$75,000
Research in space-related sciences and engineering.				
NSR-37-002-045.....	Oklahoma State University, K. A. MCCOLLOM.....	A pilot program for selecting, editing and disseminating engineering and scientific educational subject matter from NASA technical reports.	6/66- 8/68	99,500
NAS8-21391.....	Oklahoma State University.....	A study of dense aluminum plasma from hypervelocity impact and other sources.	5/68- 3/69	35,000
NGR-37-003-026.....	Oklahoma, University of, C. RIGGS.....	Multidisciplinary research program in space science and engineering.	1/68-12/70	100,000
NSR-37-004-006.....	Southeastern State College, L. B. ZINK.....	A program to enhance the transfer of new technology to potential industrial, governmental, and academic users in the Oklahoma area.	10/67- 3/68	40,000
<b>OREGON:</b>				
NAS9-8097.....	Oregon State University.....	Activation analysis of lunar material.	6/68-12/69	57,000
NGR-38-003-015.....	Oregon, University of, J. ROMAN.....	Advanced studies of physiological responses to flight stresses.	7/68-12/69	10,050
NAS9-8071.....	Oregon, University of.....	Determine temperature of rock formation by study of plagioclase properties.	6/68-12/69	30,000
<b>PENNSYLVANIA:</b>				
NGR-39-002-011....	Carnegie-Mellon University, J. J. WOLKEN.....	Microspectrophotometric techniques of studying the constituents of living cells and organelles.	4/68- 3/69	20,000
Launch window analysis of highly eccentric orbits.				
NGR-39-087-001....	Carnegie-Mellon University M. L. RENARD.....	4/68- 3/69	29,882	
NGR-39-087-002....	Carnegie-Mellon University, A. G. MILNES.....	4/68- 3/69	47,500	
Study of semiconductor, heterojunctions of ZNSE, GAAS, and GE.				
NGR-39-087-003....	Carnegie-Mellon University, J. R. LOW.....	4/68- 3/69	29,778	
Investigation of the effects of microstructure on the fracture roughness of high strength alloys.				
NAS9-8073.....	Carnegie-Mellon University.....	Determine isotope abundance of pb sr os tl nd ag by mass spectrometry.	6/68-10/69	38,000
NAS12-652.....	Carnegie-Mellon University.....	Tech. for parameter from experimental tests.	6/68- 8/69	10,000
NGL-39-004-001....	Drexel Institute of Technology, P. C. CHOU.....	Protection of liquid-filled fuel tanks against meteoroid impact.	9/68- 8/70	50,000
NGR-39-004-007....	Drexel Institute of Technology, C. GATLIN.....	Multidisciplinary research in space science and technology.	6/68- 5/71	100,000
NGR-39-004-015....	Drexel Institute of Technology, M. M. LABES.....	3/68- 2/69	30,000	
Mechanisms for the effects of electric and magnetic fields on biological systems.		3/69- 2/71	30,000	
NGR-39-007-007....	Lehigh University, R. W. KRAFT.....	7/68- 6/69	39,605	
Investigation of the solidification structure and properties of eutectic alloys, including consideration of properties control.				
NGR-39-007-025....	Lehigh University, G. C. M. SHI.....	Elastic and/or plastic analysis of fracture theories and crack problems.	9/67- 9/68	41,880
NAS9-8084.....	Lehigh University.....	Using replication and thin section electron microscopy to determine the damage in minerals and rocks due to shock.	6/68- 1/70	14,000

		<i>Agreement period</i>	<i>Amount</i>
PENNSYLVANIA—Continued			
NGR-39-008-014...	Mellon Institute, E. G. HANEY.....	8/67- 7/68	\$40,000
	Investigation of stress corrosion cracking of titanium alloys.		
NsG-134.....	Pennsylvania State University, J. S. NISBET.....	11/67-10/69	50,000
(NGR-39-009-003)	Theoretical and experimental research on electron densities in the upper ionosphere, including studies of a rocket and separating-capsule experimental technique.		
NGL-39-009-001...	Pennsylvania State University, G. F. WISLICENUS.....	4/68- 3/71	100,000
	Investigation of limited and developed cavitation.		
NGL-39-009-010...	Pennsylvania State University, D. P. GOLD.....	9/68- 8/71	36,000
	Study of structural and mineralogical signatures of meteorite impact sites including mineral paragenesis high pressure polymorphs, microfractures and quartz lamellae.		
NGL-39-009-015...	Pennsylvania State University, P. EBAUGH.....	9/67- 8/70	100,000
	Multidisciplinary space-related research.		
NGL-39-009-023...	Pennsylvania State University, J. L. SHEARER.....	10/67- 9/68	57,633
	Research and development of on-board control systems and elements for aerospace vehicles.		
NGL-39-009-032...	Pennsylvania State University, B. R. F. KENDALL.....	6/68- 3/69	45,000
	Evaluation of the constant-momentum mass spectrometer for ion analysis in the D and E regions of the ionosphere.		
NGL-39-009-034...	Pennsylvania State University, J. MARIN.....	4/68- 3/69	16,000
	Low cycle fatigue under multiaxial strain cycling.		
NGL-39-009-035...	Pennsylvania State University, R. G. QUINN.....	3/68- 2/71	30,000
	Cooperative ionospheric investigations.		
NGL-39-009-111...	Pennsylvania State University, B. W. McCORMICK.....	4/68- 3/70	68,379
	Study of rotor-blade vortex interaction.		
NGL-39-010-087...	Pennsylvania, University of, F. HABER.....	10/67- 9/68	36,531
	An angle-measurement navigation satellite concepts study.		
NGL-39-010-097...	Pennsylvania, University of, C. J. LAMBERTSEN.....	1/68-12/68	50,000
	Studies of acute acclimatization of subnormal PO <sub>2</sub> and PCO <sub>2</sub> .		
NAS5-14923.....	Pennsylvania, University of.....	4/68- 1/69	13,000
	Tech. report for frequency assignment guideline for satellite radio links.		
NSG-416.....	Pittsburgh, University of, D. HALLIDAY.....	8/67- 7/70	300,000
(NGR-39-011-002)	Interdisciplinary space-related research in the physical, life, and engineering sciences.		
NGL-39-011-013...	Pittsburgh, University of, W. L. FITE.....	2/68- 1/71	40,000
	Investigation of airglow excitation mechanisms using atomic beam techniques.		
NGL-39-011-030...	Pittsburgh, University of, E. C. ZIFF.....	5/68- 4/71	65,000
	Excitation in collisional deactivation of the measurable A <sup>3</sup> state of nitrogen in the aurora and day airglow.		
NGL-39-011-035...	Pittsburgh, University of, E. GERJUOY.....	10/67- 9/68	10,000
	New formulas for collision amplitudes and related quantities.		
NGL-39-011-039...	Pittsburgh, University of, W. G. VOGT.....	11/67-10/68	27,950
	Stability of solutions to partial differential equations.		
NASr-169.....	Pittsburgh, University of, N. WALD.....	9/67- 8/68	49,965
(NSR-39-011-005)	Automatic analysis of cytogenetic material.		
NSR-39-011-070...	Pittsburgh, University of, A. KENT.....	3/67- 3/68	195,000
	Regional dissemination center operations.		
NSR-39-011-074...	Pittsburgh, University of, A. KENT.....	2/67- 2/67	7,466
	Motion picture film clip of technology transfers.		
NSR-39-011-076...	Pittsburgh, University of.....	12/67- 1/69	61,968
	Special experimental projects involving information systems and technology utilization.		
NASI-7709.....	Temple University.....	9/67- 7/68	4,000
	The design, testing, fabrication, delivery, and launch support of a barium chemical release payload.		

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			<i>Agreement period</i>	<i>Amount</i>
PENNSYLVANIA—Continued				
NAS5-9128	Temple University	Dust particle experiments.	12/64- 6/68	\$18,000
RHODE ISLAND:				
NGR-40-002-012	Brown University, P. D. RICHARDSON	Variational methods for solving heat conduction problems.	4/67- 4/68	11,313
NGR-40-002-042	Brown University, G. S. HELLER	Properties and application of solid state materials at submillimeter frequencies.	11/67-10/68 11/68-10/70	30,000 30,000
NGR-40-002-059	Brown University, E. A. MASON	Study of short-range intermolecular forces and high-temperature gas properties.	9/68- 8/69	33,000
SOUTH CAROLINA:				
NGR-41-001-008	Clemson University J. C. MARTIN	Investigation of the use of stellar references for automatic orientation of theodolite platforms.	8/67- 8/68	26,702
NAS8-11259	Clemson University	Studies of statistical filter theory to selected problems of guidance control & navigation of space vehicle.	5/64- 4/69	10,000
NGR-41-002-003	South Carolina, University of, J. R. DURIG	Infrared spectra of molecules and materials of astrophysical interest.	6/67- 5/69	8,000
SOUTH DAKOTA:				
NGR-42-001-004	South Dakota School of Mines and Technology, R. A. Schleusener	Investigation of the application of aerospace technology to weather modification.	9/68- 8/71	100,000
TENNESSEE:				
NSG-587	Tennessee, University of, W. K. STAIR		4/68- 3/69	27,870
(NGR-43-001-003)	Theoretical and experimental studies of visco-type shaft seals.			
NGL-43-001-006	Tennessee, University of, N. M. GAILER	Theoretical and experimental very high resolution spectroscopic studies of line shapes of atmospheric gases and of absorption bands of inorganic solids.	10/67- 9/70	101,741
NGR-43-001-018	Tennessee, University of, J. E. SPRUELL	Experimental and theoretical investigation of the relation between atomic structure and the physical properties of metallic solid solutions.	3/68- 2/69	15,417
NGR-43-001-021	Tennessee, University of, C. O. THOMAS	Multidisciplinary research program in space sciences and engineering.	1/68-12/71	200,000
NGR-43-001-023	Tennessee, University of, M. W. MILLIGAN	Fundamental study in low-density gas dynamics.	5/68- 6/69	33,000
NGR-43-001-056	Tennessee, University of, F. M. SHOFNER	Investigation of noise characteristics and amplitude stabilization of plasma lasers.	9/67- 8/68 9/68- 8/70	25,000 25,000
NAS8-11189	Tennessee, University of	Search for good algorithms for practical solutions to discrete optimization problems.	4/64- 3/69	30,000
TEXAS:				
NGR-44-003-018	Baylor University, J. J. CHIDONI	Studies of liver and gastrointestinal tract irradiated with protons.	2/68- 1/69	15,000
NGR-44-003-031	Baylor University, R. ROESSLER	Physiological correlates of optimal performance.	5/68- 4/69	39,911
NAS9-7237	Baylor University	Harness system.	6/67- 3/69	19,000
NAS9-7280	Baylor University	Cell life span.	6/67- 7/69	35,000
NAS9-8109	Baylor University	Evaluation of materials for space flight apparel.	6/68-12/69	72,000

		<i>Agreement period</i>	<i>Amount</i>
TEXAS—Continued			
NGR-44-002-004	Harding College, H. D. OLREE	5/68- 4/69	\$46,440
	Methods of achieving and maintaining physical fitness for prolonged space flight.		
NsG-257	Houston, University of, J. ORO AND A. ZLATKIS	12/67-11/68	40,000
(NGR-44-005-002)	Studies in organic cosmochemistry, including compound formation under primitive earth conditions, and organic material in selected meteorites.		
NGR-44-005-022	Houston, University of, A. F. HILDEBRANT	4/68- 3/69	50,000
	Interactions of hydromagnetic wave energy with energetic plasmas, and other space-related scientific and technical investigations.		
NGR-44-005-073	Houston, University of, D. R. TRAYLOR	6/68- 5/69	50,000
	Basic research in pure and applied mathematics.		
NGR-44-005-084	Houston, University of, C. J. HUANG	8/68- 7/69	150,000
	Hybrid computation research program.		
NSR-44-005-016	Houston, University of, C. J. HUANG	4/68- 3/69	109,700
	Summer institute in space-related engineering.		
NSR-44-005-059	Houston, University of, C. J. HUANG	6/68- 8/68	109,650
	A faculty space systems engineering institute.		
NAS9-6331	Houston, University of	6/66- 6/69	3,000
	Chronologies of Projects Gemini and Apollo and a history of Project Gemini.		
NAS9-7828	Houston, University of	3/68- 2/69	48,000
	Lunar terrain study.		
NAS9-8012	Houston, University of	6/68-10/69	143,000
	A comprehensive study of the carbonaceous and organogenic matter present in returned lunar samples.		
NAS9-8069	Houston, University of	6/68-12/69	3,000
	Measurement and analysis by petrographic microscope methods of shock effects on returned lunar samples.		
NAS9-8173	Houston, University of	6/68-11/68	24,000
	Simulate ultrasonically the radar cross-section of the Apollo CSM.		
NAS9-8264	Houston, University of	6/68- 8/69	30,000
	Development of LRL protocol.		
NsG-673	Rice University, F. C. MICHEL, A. J. DESSLER	10/67- 9/68	140,000
(NGR-44-006-012)	An experimental investigation of the methodology and techniques for measuring the relative abundance of heavy ions in the solar wind.		
NGR-44-006-033	Rice University, A. J. CHAPMAN, A. J. DESSLER	9/67- 8/70	200,000
	Multidisciplinary space related research.		
NGR-44-007-076	Rice University, B. J. O'BRIEN	9/67- 8/68	9,961
	Study of short period pulsations using an image orthicon or TV system.		
NGR-44-006-088	Rice University, R. B. MCLELLAN	6/68- 5/70	178,940
	Investigation of stress corrosion in titanium alloys and other metallic materials.		
NGR-44-006-089	Rice University, A. MIELE	6/68- 5/69	30,428
	Mathematical optimization techniques for aerospace applications.		
NASr-209	Rice University, B. J. O'BRIEN	9/67- 6/68	55,165
(NSR-44-006-004)	Investigations and analyses of particle and light flux in aurorae and air-glow using rocket-borne instrumentation.		
NAS6-1061	Rice University	8/65- 9/68	425,000
	Design construction and use of two research satellites code named "Owl".	8/65- 9/68	500,000
NAS9-5884	Rice University	6/66- 6/69	224,000
	Charged-particle lunar environment experiment for ALSEP.		
NAS9-5911	Rice University	4/66- 4/69	200,000
	Suprathermal ion detector experiment for ALSEP.	4/66- 4/69	250,000
		4/66- 4/69	250,000
		4/66- 4/69	239,000

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TEXAS—Continued			<i>Agreement period</i>	<i>Amount</i>
NAS9-7738	Rice University	Electric field detector development.	2/68-11/68	\$50,000
NAS9-7899	Rice University	Preparation for the performance of a program of research involving the measurement and analysis of rare gases and samples.	4/68-10/69 4/68-10/69	42,000 10,000
NAS9-7969	Rice University	Study of sublimation through a porous surface.	5/68- 5/69	52,000
NAS2-4849	St. Thomas, University of	Biosatellite project experiment P-1159.	6/68- 1/69	51,000
NAS8-21292	St. Thomas, University of	Analysis of wind field conditions which adversely affect vehicle operations.	3/68- 3/69	59,000
NGR-44-007-006	Southern Methodist University, J. C. DENTON	Multidisciplinary research in space-related science and technology.	2/68- 1/71	100,000
NGR-44-007-027	Southern Methodist University, S. C. GUPTA	System analysis using topological structure and transform algorithms.	9/68- 8/69	9,818
NGR-44-007-028	Southern Methodist University, J. E. WALSH	Efficient estimation of distribution for extreme observations in sample and nonsample cases.	1/68-12/68	19,000
NAS12-661	Southern Methodist University	Development of a computer program for the network analysis.	4/68- 8/69	10,000
NsG-239	Texas A. & M. University, H. E. WHITMORE	Interdisciplinary space-oriented research in the physical, life and engineering sciences.	2/67- 1/70 2/68- 1/71	9,564 100,000
(N G R-44-001-001)	Texas A. & M. University, T. J. KOZIK	Analysis of structurally orthotropic shells by means of the compliance method.	12/67-11/68	45,000
NGR-44-001-036	Texas A. & M. University, R. THOMAS	Study of the simulation of atmospheric processes in a wind tunnel.	6/67- 9/68	61,700
NGR-44-001-044	Texas A. & M. University, J. A. STRICKLIN	The nonlinear static and dynamic analysis of shells of revolution with asymmetrical stiffness properties.	1/68-12/68 1/69-12/70	5,000 50,000
NGR-44-001-067	Texas A. & M. University, R. E. WAINERD	Feasibility of fast neutron activation analysis as a nondestructive testing method for alpha phase titanium alloy.	1/68- 6/68	19,283
NAS9-6812	Texas A. & M. University	Hypervelocity accelerations.	2/67- 5/68	74,000
NAS9-7951	Texas A. & M. University	Effects of spacecraft environments on patterns in bacteria.	5/68- 5/69	50,000
NAS9-8158	Texas A. & M. University	Bibliographic study on animal genera.	6/68- 1/69	41,000
NAS8-21421	Texas Christian University	Radiative interactions of electrons with matter.	6/68- 8/69	40,000
NsG-353	Texas, University of, A. A. DOUGAL	Propagation and dispersion of hydromagnetic and ion cyclotron waves in plasmas immersed in magnetic fields.	1/68- 1/69	24,343
(N G R-44-012-005)	Texas, University of, A. E. STRAITON	Research on millimeter-wavelength radiation from solar bodies.	4/68- 3/71	106,800
NsG-432	Texas, University of, B. D. TAPLEY	Study of theory and analysis of low-thrust guidance problems in deterministic linear control.	2/68- 1/69	35,010
(N G R-44-012-006)	Texas, University of, B. D. TAPLEY	Investigation of methods for defining optimal open-loop control procedures for continuous powered space flight.	2/68- 1/69	20,460

		Agreement period	Amount
<b>TEXAS—Continued</b>			
NGR-44-012-055...	Texas, University of, J. N. DOUGLAS.....	5/68- 4/69	\$85,920
	Polarization and time structure of Jovian decametric radiation and the structure of interplanetary plasma.		
NGR-44-012-079...	Texas, University of, J. M. LIPTON.....	12/67-11/68	27,000
	Temperature discrimination, behavioral thermoregulation and related measures on the rat.		
NGR-44-012-099...	Texas, University of, H. G. SPERLING.....	12/67- 5/68	41,000
	New vision test techniques for use in the space environment.		
NGR-44-012-104...	Texas, University of, W. H. HARTWIG.....	6/68- 5/69	35,000
	A study of optical properties of materials at low temperatures and their application to optical detection.		
NASr-242.....	Texas, University of, H. SMITH.....	- 9/68	400,000
(NSR-44-012-025)	Design, development, fabrication and installation at McDonald Observatory of 105-inch telescope suitable for lunar and planetary observations.		
NAS5-10387.....	Texas, University of.....	4/67- 8/68	18,000
	Boresight and alignment tests of radio telescope installation.		
NAS9-7153.....	Texas, University of.....	6/67- 9/69	50,000
	Hybrid computer development.		
NAS9-7926.....	Texas, University of.....	5/68- 5/69	28,000
	CR1 display-light pen.		
NAS9-8122.....	Texas, University of.....	6/68- 6/69	25,000
	Humoral and cellular aspects of man's immunity to manned spaceflight.		
NAS9-8200.....	Texas, University of.....	6/68- 8/69	35,000
	Personal oral hygiene requirements for extended spaceflight.		
NAS9-8258.....	Texas, University of.....	6/68- 6/69	35,000
	Blood coagulation study.		
NsG-210.....	Texas Southwestern Medical School, University of, P. O'B. MONTGOMERY.	12/67-11/68	40,000
(NGR-44-010-001)	Research on the influence of gravity on unicellular organisms, and optimization of the ultraviolet flying-spot microscope for living cell observations.		
NGR-44-013-005...	Texas Woman's University, G. P. VOSE.....	12/67-11/68	40,000
	Physical and biochemical changes occurring in human bone as a result of bed rest.		
NAS2-2711.....	Texas Woman's University.....	3/65- 2/69	36,000
	Biosatellite experiment P-1062: investigation of bone density changes in various sites of the skeletal anatomy of primates for the purpose of defining and verifying an experiment suitable for use in a biosatellite.		
NAS9-8246.....	Texas Woman's University.....	6/68- 6/69	45,000
	Programmed exercise study.		
<b>UTAH:</b>			
NGR-45-001-026...	Brigham Young University, P. O. BERRETT.....	5/68- 7/69	20,000
	Study and development of a field emission ion source for quadrupole mass spectrometer.		
NGR-45-002-011...	Utah State University, E. W. VENDELL.....	9/67- 8/68	10,696
	Boundary corrections for a three-coil conductivity/velocity plasma probe.		
NGR-45-003-019...	Utah, University of, N. W. RYAN.....	1/68-12/68	32,412
	Investigation of the combustion chemistry of composite rocket propellants.		
NGR-45-003-025...	Utah, University of, F. L. STAFFANSON.....	12/67-11/70	95,000
	Investigation of meteorological measurement techniques up to 100 kilometers.		
NGR-45-003-027...	Utah, University of, R. W. GROW.....	5/68- 4/69	25,000
	Theoretical and experimental investigation of solid-state mechanisms for generating coherent radiation in the ultraviolet and x-ray regions.		

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		<i>Agreement period</i>	<i>Amount</i>
UTAH—Continued			
N G R - 4 5 - 0 0 3 - 0 4 3	Utah, University of, E. A. SHNEOUR..... Long term kinetics of brain macromolecular residues.	7/68- 6/69	\$19,994
N A S 3 - 1 1 1 7 9	Utah, University of..... Design criteria monograph on solid rocket propellant grain design and internal ballistics.	6/67-12/68	7,000
V E R M O N T :			
N G R - 4 6 - 0 0 1 - 0 0 8	Vermont, University of, C. D. COOK..... Multidisciplinary research program in space sciences and engineering, with particular emphasis on bio-engineering.	2/68- 1/71	50,000
V I R G I N I A :			
N A S 1 - 7 2 2 1	Hampton Institute..... Conversion of government-owned VGH flight records, FY '68.	7/67- 6/68	17,000
N s G - 1 5 6	Virginia, Medical College of, J. J. P A T T E R S O N .....	1/68-12/68	25,000
M echanisms of control of the circulation of the brain.			
N G R - 4 7 - 0 0 2 - 0 2 0	Virginia, Medical College of, H. P. D A L T O N .....	6/68- 5/69	35,440
R esearch on microbiological performance testing on t he water management sub-system for a four man space c apsule.			
N G R - 4 7 - 0 0 3 - 0 0 8	Old Dominion College, R. L. W I L L I A M S .....	6/68- 5/69	27,799
S tudies in heterocyclic synthesis.			
N G R - 4 7 - 0 0 3 - 0 0 9	Old Dominion College, P. B. J O H N S O N .....	2/68- 5/68	6,068
T heoretical and experimental investigation of optimum s uperconducting thin film tunneling devices and the a pplication of EHF.			
N S R - 4 7 - 0 0 3 - 0 1 0	Old Dominion College, G. L. G O G L I A .....	1/68-12/68	97,800
A SEE - N A S A summer faculty training program in s ystems engineering.			
N S R - 4 7 - 0 0 3 - 0 1 1	Old Dominion College, G. L. G O G L I A .....	1/68-12/68	116,300
A SEE - N A S A Summer Faculty Institute.			
N G R - 4 7 - 0 0 3 - 0 1 2	Old Dominion College, R. Y. K. C H E N G .....	6/68- 5/69	31,960
I nvestigation to establish a theoretical description of s oil-tire interaction under moving wheel of aircraft.			
N G R - 4 7 - 0 0 2 - 0 0 5	Virginia Commonwealth University, W. T. H A M .....	7/67- 6/68	49,339
R adiation hazards to the eye.			
N G R - 4 7 - 0 0 2 - 0 1 8	Virginia Commonwealth University, S. W. L I P P I N C O T T .....	6/68- 5/69	65,000
M aximum permissible skin dose of penetrating elec- t ron radiation in the outer belt.			
N G R - 4 7 - 0 0 4 - 0 0 6	Virginia Polytechnic Institute, F. W. B U L L, J. A. J A C O B S ..	9/67- 8/70	80,000
M ultidisciplinary, space-related research in engineer- i ng and the physical and life sciences.			
N G R - 4 7 - 0 0 4 - 0 1 6	Virginia Polytechnic Institute, J. P. W I G H T M A N .....	6/68- 5/69	19,726
T he adsorption of gases on stainless steel in the pres- s ure range $10^{-10}$ to $3^{-3}$ TORR.			
N G R - 4 7 - 0 0 4 - 0 2 4	Virginia Polytechnic Institute, H. L. W O O D .....	9/67- 8/68	41,350
A study of the application of microwave techniques t o the measurement of solid propellant burning rates.			
N G R - 4 7 - 0 0 4 - 0 3 3	Virginia Polytechnic Institute, K. G O T O W .....	7/67- 6/70	100,000
R esearch in high energy nuclear physics.			
N G R - 4 7 - 0 0 4 - 0 4 0	Virginia Polytechnic Institute, J. C. S C H U G .....	7/68- 6/69	13,810
E lectronic structure and spectra of organic com- pounds.			
N A S 1 - 8 1 4 5	Virginia Polytechnic Institute..... Development of a small, lightweight gas detector.	6/68- 6/69	25,000
N s G - 3 4 0	Virginia, University of, R. L. R A M E Y .....	12/67-11/68	40,000
(N G R - 4 7 - 0 0 5 - 0 0 1)	Thin-film vacuum-deposited junctions.		
N G L - 4 7 - 0 0 5 - 0 1 4	Virginia, University of..... Multidisciplinary research in the space-related science and technology.	4/68- 3/71	100,000
N G R - 4 7 - 0 0 5 - 0 2 2	Virginia, University of, J. W. B E A M S .....	9/67- 8/68	40,000
I nvestigation to increase the accuracy of Newtonian g ravitational constant, G.			

		<i>Agreement period</i>	<i>Amount</i>
VIRGINIA—Continued			
N G R-47-005-026	Virginia, University of, E. S. McVEY, J. MOORE	6/68- 5/69	\$43,931
	Investigation of systems and techniques for multi-component micro-force measurements on wind tunnel models.		
N G R-47-005-029	Virginia, University of, H. M. PARKER	9/68- 8/69	165,000
	Theoretical and experimental investigation of a three-dimensional magnetic-suspension balance for dynamic-stability research in wind tunnels.		
N G R-47-005-046	Virginia, University of, S. S. FISHER	4/68- 3/70	45,000
	Research in the field of molecular collision phenomena using molecular beam techniques.		
N G R-47-005-050	Virginia, University of, E. J. GUNTER	6/68- 8/69	42,736
	Investigation of the dynamic stability of the rigid body rotor.		
N G R-47-005-059	Virginia, University of, W. L. DUREN	6/68- 5/69	20,000
	Global aspects of optimal control.		
N G R-47-005-066	Virginia, University of, L. W. FREDRICK	9/67- 9/68	17,537
	Broad and specific studies in astronomy and in related scientific and engineering fields.		
N G R-47-005-067	Virginia, University of, N. CABRERA	4/68- 3/71	150,000
	Studies in high energy physics.		
N G R-47-005-085	Virginia, University of, A. R. SAUNDERS	10/67-11/67	47,000
	Theoretical research on heterogeneous combustion.		
N G R-47-005-093	Virginia, University of, R. J. MATTAUCh	2/68- 1/69	23,536
	Investigation of the detectivity of radiation-produced defect levels in N- and P-type silicon and germanium.		
N S R-47-005-070	Virginia, University of, E. H. HENDRICKS	1/68-12/68	56,476
	Conduct of a three-week bio-space technology training program at NASA Wallops Station.		
NAS1-8134	Virginia, University of	4/68- 6/68	14,000
	Conduct a short course in acoustics and noise.		
NAS2-1554	Virginia, University of	9/64- 3/71	54,000
	Biosatellite project experiment P-1145, effect of weightlessness on gross body composition of the rat.		
NsG-567	William and Mary, College of, W. M. JONES	10/67- 9/70	100,000
	Multidisciplinary research in space sciences and technology.		
N G R-47-006-028	William and Mary, College of, H. FRIEDMAN	6/67- 5/68	11,000
	Improving performance in absolute judgment tasks.		
N G R-47-006-041	William and Mary, College of, R. T. SIEGEL	10/67- 9/70	167,000
	Research in intermediate energy physics.		
WASHINGTON:			
N G R-48-001-004	Washington State University, B. A. McFADDEN	12/67-11/68	18,156
	Study of intermediary metabolic processes in hydrogenomas facili.		
N G R-48-002-033	Washington, University of, P. W. HODGE	12/67-12/68	30,000
	Study of interplanetary dust.		
N G R-48-002-044	Washington, University of, A. HERTZBERG	11/67-10/70	70,000
	Generation of coherent radiation and the use of intense coherent radiation for the generation of plasmas.		
N G R-48-002-057	Washington, University of, A. HERTZBERG	11/67-11/68	72,380
	The study of fluid mechanical problems related to advanced concepts in aircraft.	11/68-11/70	73,000
WEST VIRGINIA:			
NsG-533	West Virginia University, J. C. LUDLUM	10/67- 9/70	50,000
(N G R-49-001-001)	Space-related studies in the physical, life, and engineering sciences.		
N G R-49-001-019	West Virginia University, W. H. MORAN	2/68- 1/69	20,000
	The effect of changing gravity and weightlessness on vasopressin control systems.		

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		<i>Agreement period</i>	<i>Amount</i>
<b>WISCONSIN:</b>			
NGR-50-001-009	Marquette University, E. C. FOUDRIAT.....	4/68- 3/69	\$29,400
	Study of problems relating to the precise determination of the attitude of a spin stabilized spacecraft.		
NSG-439	Wisconsin, University of, E. N. CAMERON.....	6/67- 6/69	1,320
(NGR-50-002-002)	Quantitative investigation of mineralogy and petrography of stone and iron meteorites.		
NGR-50-002-044	Wisconsin, University of, W. L. KRAUSCHAAR.....	1/68-12/68	124,214
	Research in cosmic and solar physics.		
NGR-50-002-078	Wisconsin, University of, E. C. DICK.....	6/68- 5/69	24,270
	A study of methods to effect a more complete and rapid detection of human infectious agents.		
NGR-50-002-086	Wisconsin, University of, D. O. CLIVER.....	11/67-10/68	35,000
	Stability of viruses in foods for space flights.		
NAS5-11068	Wisconsin, University of.....	5/68- 8/72	243,000
	Imp-H & P solar wind deuterium experiment.		
NAS5-11542	Wisconsin, University of.....	6/68- 6/69	185,000
	Meteorological measurements from satellite platforms.		
NAS9-7975	Wisconsin, University of.....	5/68-11/69	33,000
	Determine rare earth element by neutron activation analysis.		
<b>WYOMING:</b>			
NGR-51-001-008	Wyoming, University of, A. B. DENISON.....	1/68-12/68	14,981
	A study of the representatives of the group of canonical transformations.		
<b>FOREIGN:</b>			
NGR-52-042-004	Adelaide, University of, E. G. ELFORD.....	7/68- 6/69	19,970
	Measurements of the orbits of shower and sporadic meteors in the southern hemisphere by a multi-station radio technique.		
NSG-54	Auckland, University of, J. E. TITHERIDGE.....	12/67-11/68	8,000
(NGR-52-001-001)	Investigation of the propagation of radio signals from artificial satellites including consideration of ionospheric electron content and irregularities.		
NSR-52-125-001	British Columbia, University of, B. AHLBORN.....	7/67- 6/68	2,645
	Velocity measurements from the doppler shift of spectral lines with the double wedge technique.		
NGR-52-119-001	Goteborg, University of, H. HYDEN.....	2/68- 1/69	8,000
	Study of biomedical and molecular changes in the brain.		
NGR-52-012-002	Israel Institute of Technology, A. BERKOVITS.....	7/67- 6/68	12,750
	Creep behavior of metals in low-strain region under slightly varying stresses.		
NGR-52-093-001	Ottawa, University of, H. KOZLOWSKA.....	7/68- 6/69	8,333
	Role of surface oxide films in oxygen reduction and evolution.		
NSR-52-117-001	North Wales, University College of, P. R. THORNTON.....	10/67-10/68	13,750
	The further development of scanning electron microscopy in the microelectronics field.		
NGR-52-083-002	Virgin Islands, College of the, F. B. GRAY.....	11/67-10/68	34,900
	Optimization of the separator's subsystem for GC/MB life detection.		
NAS5-9930	West Indies, University of the.....	1/66- 1/69	13,000
	GEOS minitrack optical tracking system.		

